HP OpenVMS Alpha Partitioning and Galaxy Guide

OpenVMS Alpha Version 7.3-2

This manual supersedes the OpenVMS Alpha Partitioning and Galaxy Guide for Version 7.3-1.

Manufacturing Part Number: AA-REZQE-TE

September 2003

Legal Notice

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The HP OpenVMS documentation set is available on CD-ROM.

Contents

Contents

Contents

Tables

Figures

Figures

Preface

The *HP OpenVMS Alpha Partitioning and Galaxy Guide* describes how customers can take advantage of the partitioning and OpenVMS Galaxy capabilities available in OpenVMS Alpha Version 7.3–2.

The information in this document applies to OpenVMS Alpha systems only; it does not apply to OpenVMS VAX systems.

Intended Audience

This guide is intended for system managers, application programmers, technical consultants, data center managers, and anyone who wants to learn about OpenVMS Galaxy and the partitioning capabilities of OpenVMS Alpha.

Document Structure

This guide introduces OpenVMS partitioning concepts and features on the hardware platforms that support them. It also explains how to use the OpenVMS Galaxy capabilities available in OpenVMS Alpha Version 7.3–2.

This guide contains the following chapters and appendixes:

Chapter 1 describes how to use hard and soft partitions and the OpenVMS support for resource affinity domains (RADs).

Chapter 2 describes the OpenVMS Galaxy concepts and highlights the features available in OpenVMS Version 7.3–2.

Chapter 3 discusses the nonuniform memory access (NUMA) implications on OpenVMS applications.

Chapter 4 describes how to create an OpenVMS Galaxy on AlphaServer GS140/GS60/GS60E systems.

Chapter 5 describes how to create an OpenVMS Galaxy on an AlphaServer 8400 system.

Chapter 6 describes how to create an OpenVMS Galaxy on an AlphaServer 8200 system.

Chapter 7 describes how to create an OpenVMS Galaxy on an AlphaServer 4100 system.

Chapter 8 describes how to create an OpenVMS Galaxy on an AlphaServer ES40 system.

Chapter 9 describes how to create an OpenVMS Galaxy on AlphaServer GS80/160/320 systems.

Chapter 10 describes how to create an OpenVMS Galaxy on AlphaServer ES47/ES80/GS1280 systems.

Chapter 11 discusses how to use a single-instance Galaxy on any Alpha system.

Chapter 12 discusses OpenVMS Galaxy tips and techniques.

Chapter 13 describes the OpenVMS Galaxy configuration utility.

Chapter 14 describes the OpenVMS Graphical Configuration Manager.

Chapter 15 discusses CPU reassignment.

Chapter 16 describes the DCL commands that are useful for managing an OpenVMS Galaxy.

Chapter 17 describes how to communicate with shared memory.

Chapter 18 discusses the shared memory programming interfaces.

Chapter 19 describes the OpenVMS Galaxy device drivers.

Appendix A contains an OpenVMS Galaxy load balancer program example.

Appendix B lists common values for setting memory size.

Appendix C provides information on licensing.

The *HP OpenVMS Alpha Partitioning and Galaxy Guide* assumes that readers are familiar with OpenVMS concepts and operation, and does not cover basic OpenVMS information.

Related Documents

The following manuals contain OpenVMS information that might be useful for partitioned computing environments:

- *HP OpenVMS Alpha Version 7.3-2 Upgrade and Installation Manual*
- *OpenVMS Cluster Systems*
- *OpenVMS Alpha System Analysis Tools Manual*
- *OpenVMS License Management Utility Manual*

For additional information about HP OpenVMS products and services, see the following World Wide Web address:

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Conventions

The following OpenVMS conventions are intended as a baseline for use in OSSG manuals. Feel free to customize conventions for docsets other than the OpenVMS docset. You can include this list in its entirety.

The following conventions may be used in this manual:

Convention	Meaning
Ctrl/x	A sequence such as Ctrl/x indicates that you must hold down the key labeled Ctrl while you press another key or a pointing device button.

Convention	Meaning
PF1 x	A sequence such as PF1 *x* indicates that you must first press and release the key labeled PF1 and then press and release another key (x) or a pointing device button.
Return	In examples, a key name in bold indicates that you press that key.
...	A horizontal ellipsis in examples indicates one of the following possibilities: – Additional optional arguments in a statement have been omitted. – The preceding item or items can be repeated one or more times. – Additional parameters, values, or other information can be entered.
. . .	A vertical ellipsis indicates the omission of items from a code example or command format; the items are omitted because they are not important to the topic being discussed.
( )	In command format descriptions, parentheses indicate that you must enclose choices in parentheses if you specify more than one.
[ ]	In command format descriptions, brackets indicate optional choices. You can choose one or more items or no items. Do not type the brackets on the command line. However, you must include the brackets in the syntax for OpenVMS directory specifications and for a substring specification in an assignment statement.
|	In command format descriptions, vertical bars separate choices within brackets or braces. Within brackets, the choices are optional; within braces, at least one choice is required. Do not type the vertical bars on the command line.
{ }	In command format descriptions, braces indicate required choices; you must choose at least one of the items listed. Do not type the braces on the command line.
bold type	Bold type represents the introduction of a new term. It also represents the name of an argument, an attribute, or a reason.
italic type	Italic type indicates important information, complete titles of manuals, or variables. Variables include information that varies in system output (Internal error *number*), in command lines (/PRODUCER=*name*), and in command parameters in text (where (*dd*) represents the predefined par code for the device type).
UPPERCASE TYPE	Uppercase type indicates a command, the name of a routine, the name of a file, or the abbreviation for a system privilege.
`Example`	This typeface indicates code examples, command examples, and interactive screen displays. In text, this type also identifies URLs, UNIX command and pathnames, PC-based commands and folders, and certain elements of the C programming language.
–	A hyphen at the end of a command format description, command line, or code line indicates that the command or statement continues on the following line.

Convention	Meaning
numbers	All numbers in text are assumed to be decimal unless otherwise noted. Nondecimal radixes—binary, octal, or hexadecimal—are explicitly indicated.

1 Managing Workloads With Partitions

OpenVMS customers use systems that support hard and soft partitions in many different ways. To most effectively use these systems, customers can decide which configuration options best meet their computing and application needs.

This chapter describes how to use hard and soft partitions and OpenVMS support for **resource affinity domains (RADs)** to ensure that applications run as efficiently as possible on the new AlphaServer systems.

Using Hard and Soft Partitions on OpenVMS Systems

Hard partitioning is a physical separation of computing resources by hardware-enforced access barriers. It is impossible to read or write across a hard partition boundary, and there is no resource sharing between hard partitions.

Soft partitioning is a separation of computing resources by software-controlled access barriers. Soft partitions (subpartitions in some contexts) enable the sharing of hardware resources among several operating systems. Read and write access across a soft partition boundary is controlled by the operating system or applications. OpenVMS Galaxy is an implementation of soft partitioning.

How customers choose to partition their new AlphaServer ES or GS series systems depends on their computing environments and application requirements. When planning for partitioning, the amount of memory required by the applications and which operating system to run should be considered. When deciding how to configure an OpenVMS system that supports partitioning, look at the following questions:

- How many hard partitions do I need?
- How many soft partitions do I need?
- How small can I make the partitions?

Multiple hard partitions provide the maximum hardware security between partitions. A single soft partition running in a hard partition is equivalent to its running in a dedicated machine.

Multiple soft partitions within a given hard partition allow sharing resources such as CPUs and memory, and provide performance advantages.

OpenVMS Partitioning Guidelines

Hard partitioning is available only on AlphaServer ES47/ES80/GS1280 and GS80/160/320 systems. Using partitions on AlphaServer ES47/ES80/GS1280 systems is similar to using partitions on GS80/160/320 systems.

When deciding whether to use hard or soft partitions on AlphaServer ES or GS series systems, note the following:

- For the AlphaServer GS80/160/320, each partition (hard or soft) must have its own console line; for AlphaServer ES47/ES80 and GS1280 systems, a network connection to the console or direct console access is needed. For the AlphaServer GS80/160/320, each QBB in the system can have one console line.
- You can have multiple soft partitions within a hard partition.
- As an example of the licensing policy, you only need one cluster license for the entire AlphaServer ES or GS series system. It does not matter how many instances exist or how they are clustered, internally or externally. For additional information on licensing, see Appendix C of this manual and the licensing policy itself.

NOTE In an OpenVMS Galaxy computing environment, MOP (Maintenance Operations Protocol) Booting is only supported on Instance 0.

- Hard partitions should be on **building block boundaries** either on quad (QBB) or system (SBB) building blocks. GS80/160/320 systems use QBBs, and ES47/ES80/GS1280 systems use SBBs. A hard partition can contain more than one SBB or QBB. For high availability, HP recommends that hard partitions be created on system building block boundaries. No partition can have more than 32 processors.

  Only the GS1280 can use subsystem building blocks (SSBBs). A subsystem building block in a GS1280 is a 2P building block within an 8P building block.

  The AlphaServer ES47/ES80 system uses two-processor (2P) system building blocks, and the GS1280 uses eight-processor (8P) SBBs. A 2P SBB includes some I/O, but with an 8P SBB, the user must supply external I/O connections. Both subsystem and system building blocks can be used for hard partitions to provide fault isolation. See Table 1-1 for the two types of SBBs with their variants.
- Soft partitions do not have to be on building block boundaries.

Table 1-1 System Building Blocks

System	SBB Type	Model	Maximum Number of Hard Partitions
ES47/ES80	2P (2x1)	2	1
	2P (2x2)	4	2
ES80	2P (2x3)	6	3
	2P (2x4)	8	4
GS1280	8P (8x1)	8	4 - using 2P SSBBs
	8P (8x2)	16	8 - using 2P SSBBs
	8P (8x1)	8	1 - using 8P SBBs
	8P (8x2)	16	2 - using 8P SBBs
	8P (8x4)	32	4 - using 8P SBBs

Setup for partitions must follow setup rules.

For QBB-based systems, each partition (hard or soft) must have its own console line. Note that each QBB in the system can have one console line in it. Therefore, the maximum number of partitions (hard or soft) in the system equals the number of QBBs in the system.

Hard Partition Rules:

Each hard partition must have:

- Console access with the Management Backplane Module (MBM) or telnet
- An I/O drawer per partition (an internal drawer on the ES47/ES80 is sufficient).
- To avoid single points of failure, you must set up on building block boundaries.

For maximum fault isolation and availability, ES47/ES80/GS1280 systems should be hard partitioned on system building block boundaries. For the ES47/ES80, this means on the 2P SBB boundary. For the GS1280, it is the 8P SBB boundary. When configured on system building block boundaries, hard partitions will have no single points of failure for the entire system. Power and cooling are self-contained within the hard partition. The interprocessor links will be turned off. This is the most robust form of partitioning. Note that a robust hard partition may contain multiple system building blocks.

For the GS1280 system, it is possible to hard partition the system building blocks into subsystem building blocks (SSBBs). An 8P SBB may be partitioned down to the 2P level. These hard partitions are separately powered and offer the ability to power off a dual-CPU module if needed for repair. This level of partitioning does not offer the fault isolation and robustness of a system that is partitioned on 8P SBB boundaries.

For hard partitions at the 8P or 2P SBB level, an individual serial console line per hard partition is supported. When an 8P SBB is subpartitioned into multiple hard partitions, the serial console can only connect to one subpartition at a time. If simultaneous access to all subpartition consoles is needed, then telnet sessions across the management LAN must be used. The section "Process for Partition Setup" on page 20 describes the partition setup process, and the section "Hard Partition Configuration Example" on page 22 illustrates configuration setup with two examples.

NOTE *Required Console:*

Hard partitioning capability on the ES47/ES80/GS1280 Series requires a minimum of the V6.6 console set, which is available at the AlphaServer firmware Web site:

```
http://ftp.digital.com/pub/Digital/Alpha/firmware/readme.html
```

Note that this Web site address is case sensitive.

Soft Partition Rules:

Each soft partition must have:

- Console access with the MBM or telnet.
- An I/O drawer per partition (an internal drawer on the ES47/ES80 is sufficient).
- A primary CPU.
- Private and shared memory for the operating system and applications. Shared memory is not necessary for independent instances but is required for shared memory applications.

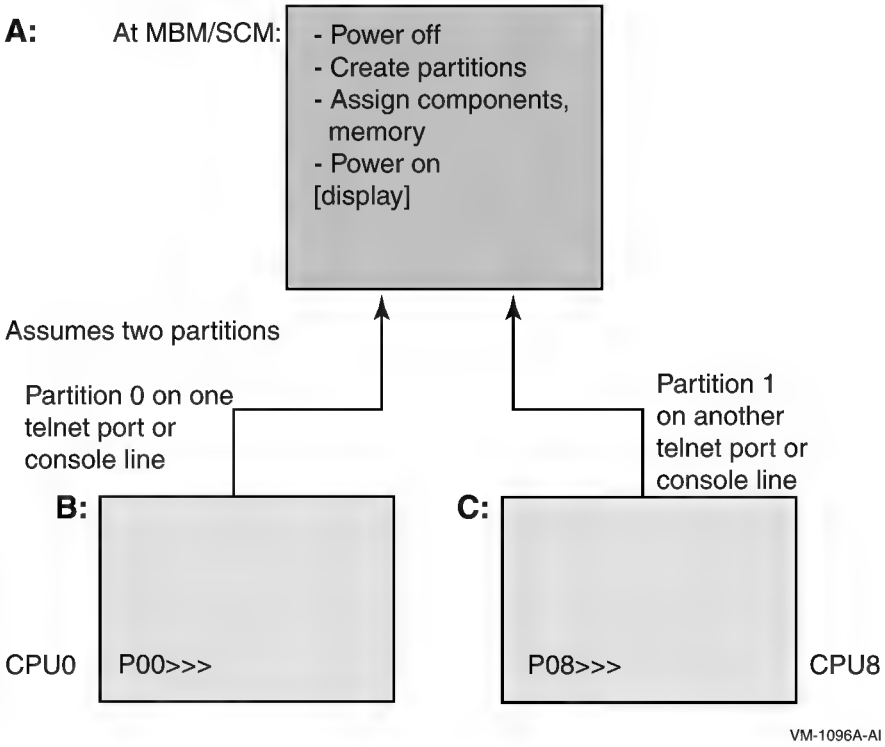
Process for Partition Setup

The basic process for setting up hard and soft partitions at the Management Backplane Module (MBM or SCM) is the following:

1. Create hard and soft partitions.
2. Assign CPU, IO, and memory resources to the partitions.
3. Power on CPUs and connect to consoles.
4. Check and reset console environment variables if necessary.

This process is illustrated in Figure 1-1.

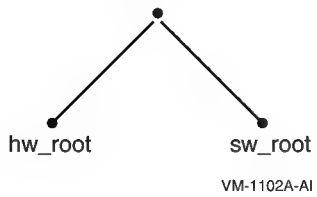
Figure 1-1 Partitioning Sequence



Physical hardware and ownership relationships are represented as branches of a single configuration tree in each system. Partitions, both hard and soft, can be thought of as ownership containers representing the accessibility and visibility of all resources in the configuration.

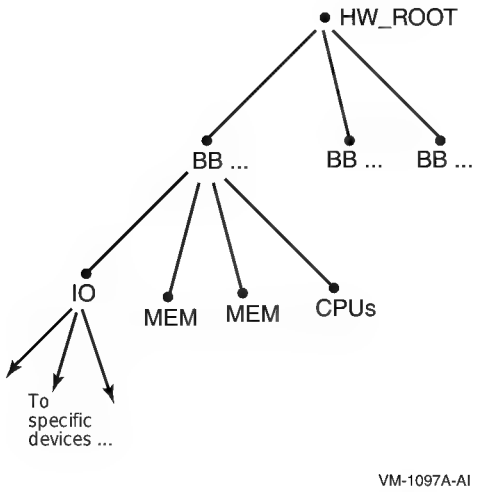
The top level configuration branch shown in Figure 1-2 includes both the hardware and software configuration trees.

Figure 1-2 System Configuration Tree



In the hardware configuration tree shown in Figure 1-3, the physical nature of the box is delimited. Each bullet or filled circle represents a **node** in the tree (where node is not an individual computer but a point of connection in the tree). From the hardware root the tree divides to the building blocks, and within each building block to the major system categories such as memory, input/output, and CPU. At a lower level in the configuration tree, within I/O, for example, the tree branches to individual devices on the system, and so on. Each node in the tree has a definition that includes its parent, its siblings, its children, and its ownership.

Figure 1-3 Hardware Configuration Tree



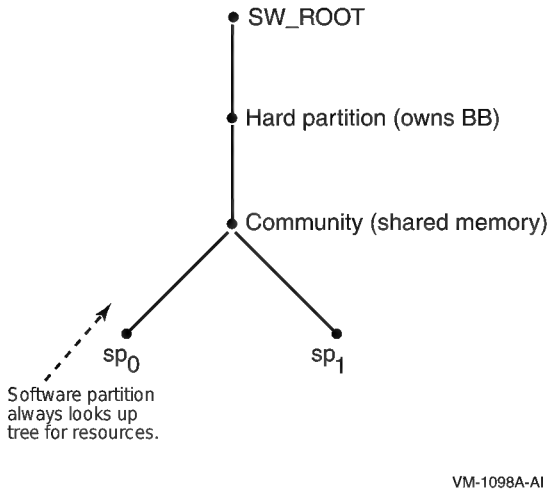
The scope of a partition is always on a branch, up or down, but never across branches. A soft partition, as shown in Figure 1-4, always looks up its tree for potentially available resources. The hard partition owns assigned resources that are available to all nodes below it.

In general, resources that are in use by a specific instance of an operating system are owned by the soft partition that represents that partition in the configuration tree. The cooperative **push model** in effect with multiple instances in a hard partition dictates that resources owned by a given instance can only be given away, not taken. A resource owned by nodes further up the tree may be used cooperatively (for example, shared memory at the community level), assigned down the tree to a specific soft partition, or up the tree where it becomes available to potentially multiple soft partitions.

Direct assignment of resources between soft partitions is called migration; only CPUs can move between soft partitions. The migration partitioning feature is not specific to Galaxy: CPUs can be migrated from any soft partition to another in the same hard partition without direct communication between them. All management of CPU resources is initiated with OpenVMS DCL `SET/STOP CPU` commands.

NOTE *Migration Restriction for ES47/ES80/GS1280 Systems:*
You cannot migrate a CPU that has attached IO. To check if there is attached IO, either check the physical configuration for a hose attached to a CPU, or use the MBM show partition output: in the IOPs section, a CPU with attached IO has a dashed line; the CPU ID is the corresponding PID in the CPUs section of the show partition output. (See "Hard Partition Configuration Example" on page 22 for an example.)

Figure 1-4 Software Configuration Tree



Partitioning for the AlphaServer ES47/ES80/GS1280

Hard Partition Configuration Example

The following example illustrates setup of hard partitions on ES47/ES80/GS1280 systems. For information on using GCM, the Graphical Configuration Manager, to view and manage a partitioned configuration, see the GCM chapter of this document. For soft partition setup, see Chapter 10.

The following example shows setup of three hard partitions on a 32-processor system. Two partitions have eight processors each; the other partition has 16 processors. The partitions are assigned on 8P SBB boundaries.

For information on the server management command line interface (CLI), see the reference manual available at the following location:

`http://mediadocs.mro.cpqcorp.net/doc_library/GS1280/ServerMgnt/CLI_Reference.pdf`

Hard and soft partition names are limited to 19 characters (alphanumeric and underscore only).

NOTE The server management CLI is case insensitive.

In this example, the consoles can be accessed on telnet ports 323, 324, and 325. The hard partitions are called *part0*, *part1,* and *part2*; each is created with the default of 255 CPUs. The subpartition type is soft. CPU and IO resources are then assigned to each partition. The `assign component` command assigns the entire SBB to the component; in the example, each drawer in the cabinet has 8 processors.

Please refer to the CLI_Reference.pdf manual mentioned earlier for changes to these commands.

```
Welcome - GS1280 Server Manager - T2.1-5
MBM> create partition -hp part0 255 soft
MBM> create partition -hp part1 255 soft
```

```
MBM> create partition -hp part2 255 soft
MBM> assign component -hp part0 -cabinet 0 -drawer 0 sbb
MBM> assign component -hp part1 -cabinet 0 -drawer 1 sbb
MBM> assign component -hp part2 -cabinet 0 -drawer 2 sbb
MBM> assign component -hp part2 -cabinet 0 -drawer 3 sbb
MBM> show partition
-----------------------------------------------------------------


Hard Partition : HP Name = part0, HP No.= 0, SP count = 2
Attributes     : max CPUs = 16, SP type = soft, Non-stripe
Physical Memory: 16384MB (16.000GB)
 Community Memory: 0MB (0.000GB)
 Sub Partition: HP Name = part0, HP No.= 0
                SP Name = Default_SP, SP No.= 0
                State = Not Running, Telnet port = 323
 Assigned Memory: unspecified

 CPUs:

     Cab  Drw  CPU   (NS,EW)   PID    Type
      0    0    0    ( 0,0 )     0    Non-primary
      0    0    2    ( 0,1 )     2    Non-primary
      0    0    4    ( 0,2 )     4    Non-primary
      0    0    6    ( 0,3 )     6    Non-primary
      0    0    1    ( 1,0 )     1    Non-primary
      0    0    3    ( 1,1 )     3    Non-primary
      0    0    5    ( 1,2 )     5    Non-primary
      0    0    7    ( 1,3 )     7    Non-primary
 IOPs:

            SBB                            PCI Drawer
     Cab  Drw  IOP   (NS,EW)             Cab  Drw  IOR
      0    0    0    ( 0,0 ) ---------   2    4    0
      0    0    2    ( 0,1 )
      0    0    4    ( 0,2 )
      0    0    6    ( 0,3 )
      0    0    1    ( 1,0 )
      0    0    3    ( 1,1 )
      0    0    5    ( 1,2 )
      0    0    7    ( 1,3 )
 Sub Partition: HP Name = part0, HP No.= 0
                SP Name = Free_Pool, SP No.= 255
                State = Not Running
  Free Memory: 0MB (0.000GB)
  CPUs: None
  IOPs: None
-----------------------------------------------------------------
Hard Partition : HP Name = part1, HP No.= 1, SP count = 2
Attributes     : max CPUs = 16, SP type = soft, Non-stripe
Physical Memory: 16384MB (16.000GB)

 Community Memory: 0MB (0.000GB)
 Sub Partition: HP Name = part1, HP No.= 1
                SP Name = Default_SP, SP No. = 0
                 State = Not Running, Telnet port = 324

 Assigned Memory: unspecified

 CPUs:

     Cab  Drw  CPU   (NS,EW)   PID    Type
      0    0    0    ( 2,0 )     0    Non-primary
      0    0    2    ( 2,1 )     2    Non-primary
      0    0    4    ( 2,2 )     4    Non-primary
      0    0    6    ( 2,3 )     6    Non-primary
      0    0    1    ( 3,0 )     1    Non-primary
```

```
      0    0    3    ( 3,1 )     3    Non-primary
      0    0    5    ( 3,2 )     5    Non-primary
      0    0    7    ( 3,3 )     7    Non-primary
 IOPs:

            SBB                            PCI Drawer
     Cab  Drw  IOP   (NS,EW)           Cab  Drw  IOR
      0    1    0    ( 2,0 ) ---------  2    5    0
      0    1    2    ( 2,1 )
      0    1    4    ( 2,2 )
      0    1    6    ( 2,3 )
      0    1    1    ( 3,0 )
      0    1    3    ( 3,1 )
      0    1    5    ( 3,2 )
      0    1    7    ( 3,3 )

 Sub Partition: HP Name = part1, HP No.= 1
                SP Name = Free_Pool, SP No. = 255
                State = Not Running
 Free Memory: 0MB (0.000GB)
 CPUs: None
 IOPs: None
-----------------------------------------------------------------

Hard Partition : HP Name = part2, HP No.= 2, SP count = 2
Attributes     : max CPUs = 16, SP type = soft, Non-stripe
Physical Memory: 36864MB (36.000GB)
 Community Memory: 0MB (0.000GB)
 Sub Partition: HP Name = part2, HP No.= 2
                SP Name = Default_SP, SP No.= 0
                State = Not Running, Telnet port = 325
 Assigned Memory: unspecified
 CPUs:
     Cab  Drw  CPU   (NS,EW)   PID    Type
      0    2    0    ( 0,4 )    0    Non-primary
      0    2    2    ( 0,5 )    2    Non-primary
      0    2    4    ( 0,6 )    4    Non-primary
      0    2    6    ( 0,7 )    6    Non-primary
      0    2    1    ( 1,4 )    1    Non-primary
      0    2    3    ( 1,5 )    3    Non-primary
      0    2    5    ( 1,6 )    5    Non-primary
      0    2    7    ( 1,7 )    7    Non-primary
      0    3    0    ( 2,4 )    8    Non-primary
      0    3    2    ( 2,5 )   10    Non-primary
      0    3    4    ( 2,6 )   12    Non-primary
      0    3    6    ( 2,7 )   14    Non-primary
      0    3    1    ( 3,4 )    9    Non-primary
      0    3    3    ( 3,5 )   11    Non-primary
      0    3    5    ( 3,6 )   13    Non-primary
      0    3    7    ( 3,7 )   15    Non-primary
 IOPs:
            SBB                            PCI Drawer
    Cab  Drw  IOP   (NS,EW)           Cab  Drw  IOR
     0    2    0    ( 0,4 ) ---------  2    6    0
     0    2    2    ( 0,5 )
     0    2    4    ( 0,6 )
     0    2    6    ( 0,7 )
     0    2    1    ( 1,4 )
     0    2    3    ( 1,5 )
     0    2    5    ( 1,6 )
     0    2    7    ( 1,7 )
     0    3    0    ( 2,4 ) ---------  2    7    0
     0    3    2    ( 2,5 )
     0    3    4    ( 2,6 )
     0    3    6    ( 2,7 )
```

```
     0    3    1    ( 3,4 )
     0    3    3    ( 3,5 )
     0    3    5    ( 3,6 )
     0    3    7    ( 3,7 )
Sub Partition: HP Name = part2, HP No.= 2
               SP Name = Free_Pool, SP No.= 255
               State = Not Running
 Free Memory: 0MB (0.000GB)
 CPUs: None
 IOPs: None
MBM> save partition
```

The system is then powered on and diagnostics run.

```
MBM> power on -all
[2003/04/16 08:05:31]
~PCO-I-(pco_04) Powering on partition. HP: part0
[2003/04/16 08:05:32]
~PCO-I-(pco_03) Powering on partition. HP: part1
[2003/04/16 08:05:32]
~PCO-I-(pco_01) Powering on partition. HP: part2
[2003/04/16 08:05:51]
~PCO-I-(pco_04) Running diagnostics on HP: part0
[2003/04/16 08:05:55]
~PCO-I-(pco_03) Running diagnostics on HP: part1
[2003/04/16 08:06:00]
~PCO-I-(pco_01) Running diagnostics on HP: part2
[2003/04/16 08:06:50]
~PCO-I-(pco_04) Diagnostics completed on HP: part0
[2003/04/16 08:06:50]
~PCO-I-(pco_04) HP:part0 SP:Default_SP Primary is NS:0 EW:0
 which is cab:00 drw:0 cpu:0 [2003/04/16 08:06:51]
~PCO-I-(pco_04) Loading SRM on Primary for HP: part0,
 SP: Default_SP. [2003/04/16 08:06:54]
~PCO-I-(pco_03) Diagnostics completed on HP: part1
2003/04/16 08:06:54]
~PCO-I-(pco_03) HP:part1 SP:Default_SP Primary is NS:2 EW:0
 which is cab:00 drw:1 cpu:0 [2003/04/16 08:06:54]
~PCO-I-(pco_03) Loading SRM on Primary for HP: part1,
 SP: Default_SP. [2003/04/16 08:06:55]
~PCO-I-(pco_04) Powered On HP:part0
[2003/04/16 08:06:59]
~PCO-I-(pco_03) Powered On HP:part1
[2003/04/16 08:07:24]
~PCO-I-(pco_01) Diagnostics completed on HP: part2
[2003/04/16 08:07:25]
~PCO-I-(pco_01) HP:part2 SP:Default_SP Primary is NS:0 EW:4
 which is cab:00 drw:2 cpu:0 [2003/04/16 08:07:25]
~PCO-I-(pco_01) Loading SRM on Primary for HP: part2,
 SP: Default_SP. [2003/04/16 08:07:29]
~PCO-I-(pco_01) Powered On HP:part2
MBM>
```

Partitioning for the AlphaServer GS80/160/320

Each hard partition requires the following:

- A standard COM1 UART console line for each partition.

- A PCI drawer for each partition.
- An I/O module per partition.
- At least one CPU module per partition.
- At least one memory module per partition.

  Memory options should be selected in the context of an application's sensitivity to memory bandwidth and memory capacity, and the number of hardware partitions. This determines the number of memory base modules and upgrades needed. The total capacity required determines the size of the arrays to be chosen.

  Memory modules should be configured in powers of 2: That is, 0, 1, 2, or 4 base modules in a QBB. Upgrades should also be installed in powers of 2: 0, 1, 2, or 4 base modules in a QBB.

The following sections describe three hard partition configuration examples:

- Example configuration 1 has four QBBs and four hard partitions. Each hard partition contains one QBB.
- Example configuration 2 has four QBBs and two hard partitions. Each hard partition contains two QBBs.
- Example configuration 3 has four QBBs and two hard partitions. One partition contains one QBB, and the other contains three QBBs.

For more information about the partitioning procedures described in this section, see the *AlphaServer GS80/160/320 Firmware Reference Manual.*

Hard Partition Configuration Example 1

The example configuration in Figure 1-5 uses four QBBs to configure four hard partitions. Each hard partition contains one QBB.

Figure 1-5 Configuration Example 1

NODE	HP	QBB
WILD7	0	0
WILD8	1	1
WILD9	2	2
WILD10	3	3

VM-1061A-AI

To configure an AlphaServer GS160 system with four hard partitions, enter the following sequence of SCM commands.

From the SCM console, enter the following settings for the *hp* NVRAM variables. Note that the values are bit masks.

```
SCM_E0> power off -all

SCM_E0> set hp_count 4
SCM_E0> set hp_qbb_mask0 1
SCM_E0> set hp_qbb_mask1 2
SCM_E0> set hp_qbb_mask2 4
SCM_E0> set hp_qbb_mask3 8
SCM_E0> set hp_qbb_mask4 0
SCM_E0> set hp_qbb_mask5 0
SCM_E0> set hp_qbb_mask6 0
```

```
SCM_E0> set hp_qbb_mask7 0

SCM_E0> power on -all
```

You can also power on or off individual hard partitions. For example, using this configuration, enter:

```
SCM_E0> power off -all
SCM_E0> set hp_count 4
SCM_E0> set hp_qbb_mask0 1
SCM_E0> set hp_qbb_mask1 2
SCM_E0> set hp_qbb_mask2 4
SCM_E0> set hp_qbb_mask3 8
SCM_E0> set hp_qbb_mask4 0
SCM_E0> set hp_qbb_mask5 0
SCM_E0> set hp_qbb_mask6 0
SCM_E0> set hp_qbb_mask7 0
SCM_E0> power on -partition 0
SCM_E0> power on -partition 1
SCM_E0> power on -partition 2
SCM_E0> power on -partition 3
```

During the powering up phases of each hard partition, status information is displayed showing how the partitions are coming on line. Pay close attention to this information and confirm that there are no failures during this process.

As each hard partition comes on line, you can start working with that hard partition's console device. Also note, that depending on the setting of the NVRAM variable AUTO_QUIT_SCM, each hard partition's console comes on line in either the SCM or SRM console mode.

From each hard partition's console, enter into the SRM console and configure any console variables specific to that hard partition. After that, boot OpenVMS in each hard partition according to standard OpenVMS procedures. For example:

The typical hard partition 0 SRM console settings for OpenVMS are:

```
P00>>>show bootdef_dev
bootdef_dev             dkb0.0.0.3.0
P00>>>show boot_osflags
boot_osflags            0,0
P00>>>show os_type
os_type                 OpenVMS
```

The typical hard partition 1 SRM console settings for OpenVMS are:

```
P00>>>show bootdef_dev
bootdef_dev             dkb0.0.0.3.0
P00>>>show boot_osflags
boot_osflags            1,0
P00>>>show os_type
os_type                 OpenVMS
```

The typical hard partition 2 SRM console settings for OpenVMS are:

```
P00>>>show bootdef_dev
bootdef_dev             dkb0.0.0.3.0
P00>>>show boot_osflags
boot_osflags            2,1
P00>>>show os_type
os_type                 OpenVMS
```

The typical hard partition 3 SRM console settings for Tru64 UNIX are:

```
P00>>>show bootdef_dev
bootdef_dev             dka0.0.0.1.16
P00>>>show boot_osflags
boot_osflags            A
P00>>>show os_type
os_type                 UNIX
```

Hard Partition Configuration Example 2

The example configuration in Figure 1-6 uses four QBBs to configure two hard partitions. Each hard partition contains two QBBs.

Figure 1-6 Configuration Example 2

NODE	HP	QBB
WILD7	0	0, 1
WILD8	1	2, 3

VM-1063A-AI

To configure an AlphaServer GS160 with two hard partitions, perform the following sequence of SCM commands.

From the SCM console, enter the following settings for the *hp* NVRAM variables:

```
SCM_E0> power off -all

SCM_E0> set hp_count 2
SCM_E0> set hp_qbb_mask0 3
SCM_E0> set hp_qbb_mask1 c
SCM_E0> set hp_qbb_mask2 0
SCM_E0> set hp_qbb_mask3 0
SCM_E0> set hp_qbb_mask4 0
SCM_E0> set hp_qbb_mask5 0
SCM_E0> set hp_qbb_mask6 0
SCM_E0> set hp_qbb_mask7 0

SCM_E0> power on -all
```

As each hard partition comes on line, you can start working with that hard partition's console device.

From each hard partition's console, you enter, as in configuration example 1, into the SRM console, and configure any console variables specific to that hard partition, and then boot OpenVMS in each hard partition.

Hard Partition Configuration Example 3

As in configuration example 2, the configuration in Figure 1-7 uses four QBBs to configure two hard partitions; the only difference is the changing of the number of QBBs per hard partition.

Figure 1-7 Configuration Example 3

NODE	HP	QBB
WILD7	0	0, 1, 2
WILD8	1	3

VM-1062A-AI

To configure an AlphaServer GS160 system, perform the following sequence of SCM commands.

From the SCM console, enter the following settings for the *hp* NVRAM variables:

```
SCM_E0> power off -all

SCM_E0> set hp_count 2
SCM_E0> set hp_qbb_mask0 7
SCM_E0> set hp_qbb_mask1 8
SCM_E0> set hp_qbb_mask2 0
SCM_E0> set hp_qbb_mask3 0
SCM_E0> set hp_qbb_mask4 0
SCM_E0> set hp_qbb_mask5 0
SCM_E0> set hp_qbb_mask6 0
SCM_E0> set hp_qbb_mask7 0

SCM_E0> power on -all
```

As in the other examples, as each hard partition comes on line, you can start working with that hard partition's console device.

From each hard partition's console, you enter, as in configuration example 1, into the SRM console, and configure any console variables specific to that hard partition, and then boot OpenVMS in each hard partition.

Updating Console Firmware on AlphaServer GS80/160/320 Systems

To update the SRM console firmware on a system that is hard partitioned, you must do so separately for each hard partition. There is no way to update all of the firmware on each partition at one time.

OpenVMS Galaxy Support

OpenVMS Galaxy software controls operating system instances through shared memory; it implements a resource-sharing association between instances in multiple soft partitions. Multiple independent operating system instances can run in multiple soft partitions without Galaxy. For additional information about OpenVMS Galaxy concepts, see Chapter 2. To create multiple soft partitions, use the Galaxy procedures as described in Chapters 4 through 10, depending on your hardware.

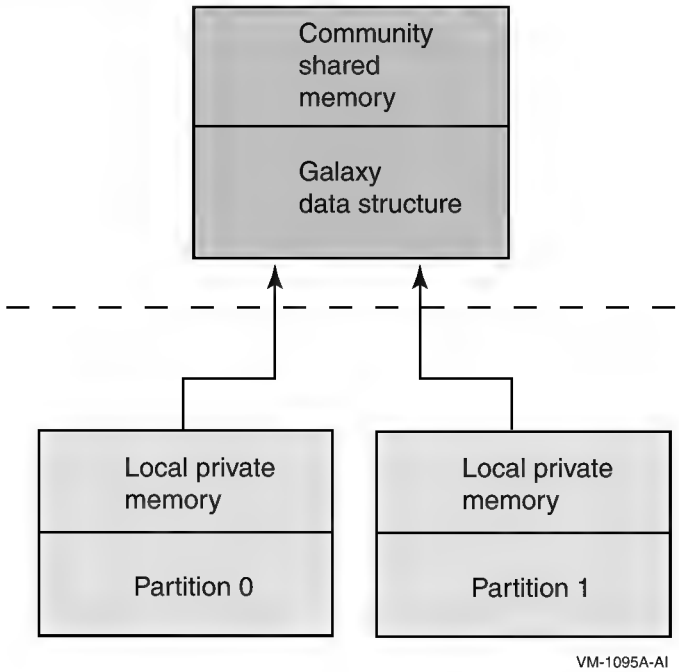
The configuration tree enables the manipulation of resources up and down the tree within each hard partition. The tree defines a hierarchy of physical connectivity and resource ownership. Hardware resources can be assigned ownership at one of several levels, although resources are allocated and used by an instance. An instance is an operating system running within a soft partition.

Software partitions govern system resources. CPUs are used only when owned by a soft partition and manipulated by the instance running there; however, CPUs may be owned by higher levels of the configuration tree — making them visible and available to all instances equally. If boot ownership is not set before a platform box is powered up, and a CPU module is later added to the system, that CPU is owned by the hardware partition to which it was added, and it is programmatically assignable to any of the soft partitions within that hard partition. (The ES47/ES80/GS1280 does not support hot swap of components.)

As soon as an instance of the operating system boots, all its resources are exclusively owned by the soft partition to which it is assigned: only that instance can manipulate its state characteristics. Consequently, it is important to consider the initial allocation of CPUs at powerup — even those that do not currently exist — to provide the best division of resources when they become available.

To create multiple soft partitions within a single hard partition, use standard partitioning procedures, as previously described, to create Galaxy configurations with instances running in these soft partitions. Figure 1-8 illustrates how memory is used in a Galaxy instance. Soft partitions require the OpenVMS minimum for memory.

Figure 1-8 How Memory Is Used



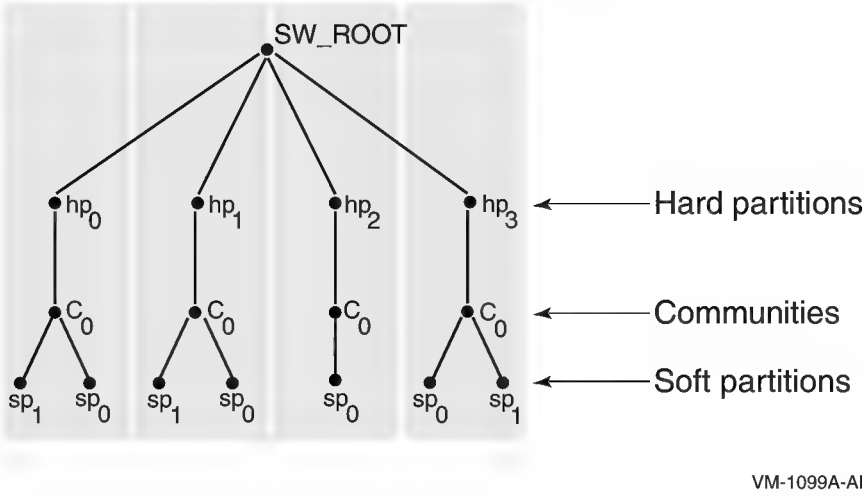
The Galaxy ID is within the hard partition and can span the hard partition. That is, if you have two hard partitions and you run Galaxy in both, each Galaxy will have its own unique Galaxy ID. Keep this in mind when you use network management tools; they will also see two Galaxy environments when two Galaxy IDs exist.

Figure 1-9 illustrates four hard partitions (0, 1, 2, 3), each of which has a unique name such as hp_0. Within hard partition 0, a Galaxy is shown that contains two soft partitions, the left-most sp_1 and sp_0. Other Galaxies exist in each of the other hard partitions, as could multiple independent operating system instances if none of them creates or joins a Galaxy. You can run an operating system instance in any soft partition.There is one Galaxy per community because the shared memory used by the Galaxy is owned by the community. This makes it visible and accessible to all instances in the Galaxy membership. All instances running in soft partitions below the community node are potentially eligible to join the Galaxy there. Member

nodes may take advantage of the shared resources controlled by the Galaxy. Although independent instances are still able to assign and migrate CPUs, only members of the Galaxy can take advantage of the benefits of shared memory.

There can be only one community per hard partition.

Figure 1-9 Soft Partitioning in the Configuration Tree



OpenVMS Application Support for Resource Affinity Domains (RADs)

The large amount of physical memory in the new AlphaServer GS series systems provides opportunities for extremely large databases to be completely in memory. The AlphaServer **nonuniform memory access (NUMA)** system architecture provides the bandwidth to efficiently access this large amount of memory. NUMA is an attribute of a system in which the access time to any given physical memory is not the same for all CPUs.

In OpenVMS Alpha Version 7.2–1H1, OpenVMS engineering added NUMA awareness to OpenVMS memory management and process scheduling. This capability (application support for RADs) ensures that applications running in a single instance of OpenVMS on multiple building blocks can execute as efficiently as possible in a NUMA environment.

The operating system treats the hardware as a set of resource affinity domains (RADs). A RAD is a set of hardware components (CPUs, memory, and I/O) with common access characteristics. On AlphaServer GS80/160/320 systems, a RAD corresponds to a quad building block (QBB). On AlphaServer ES47/ES80/GS1280 systems, a RAD corresponds to a two-processor CPU board. A CPU references memory in the same RAD roughly up to three times faster than it references memory in another RAD. Therefore, it is important to keep the code being executed and the memory being referenced in the same RAD as much as possible while not giving some processes a consistently unfair advantage. Good location is the key to good performance, but it must be as fair as possible when fairness is important.

The OpenVMS scheduler and the memory management subsystem work together to achieve the best possible location by:

- Assigning each process a preferred or "home" RAD.
- Assigning process-private pages from the home RAD's memory.
- Usually scheduling a process on a CPU in its home RAD.
- Replicating operating system read-only code on each RAD.
- Distributing global pages over RADs.
- Striping reserved memory over RADs.

For more information about using the OpenVMS RAD application programming interfaces, see Chapter 3.

2 OpenVMS Galaxy Concepts

The HP Galaxy Software Architecture on OpenVMS Alpha lets you run multiple instances of OpenVMS in a single computer. You can dynamically reassign system resources, mapping compute power to applications on an as-needed basis without having to reboot the computer.

This chapter describes OpenVMS Galaxy concepts and highlights the features available in OpenVMS Alpha Version 7.3.

OpenVMS Galaxy Concepts and Components

With OpenVMS Galaxy, software logically **partitions** CPUs, memory, and I/O ports by assigning them to individual instances of the OpenVMS operating system. This partitioning, which a system manager directs, is a software function; no hardware boundaries are required. Each individual instance has the resources it needs to execute independently. An OpenVMS Galaxy environment is **adaptive** in that resources such as CPUs can be dynamically reassigned to different instances of OpenVMS.

The Galaxy Software Architecture on OpenVMS includes the following hardware and software components:

Console

The **console** on an OpenVMS system is comprised of an attached terminal and a firmware program that performs power-up self-tests, initializes hardware, initiates system booting, and performs I/O services during system booting and shutdown. The console program also provides run-time services to the operating system for console terminal I/O, environment variable retrieval, NVRAM (nonvolatile random access memory) saving, and other miscellaneous services.

In an OpenVMS Galaxy computing environment, the console plays a critical role in partitioning hardware resources. It maintains the permanent configuration in NVRAM and the running configuration in memory. The console provides each instance of the OpenVMS operating system with a pointer to the running configuration data.

Shared memory

Memory is logically partitioned into private and shared sections. Each operating system instance has its own private memory; that is, no other instance maps those physical pages. Some of the shared memory is available for instances of OpenVMS to communicate with one another, and the rest of the shared memory is available for applications.

The Galaxy Software Architecture is prepared for a nonuniform memory access (NUMA) environment and, if necessary, provides special services for such systems to achieve maximum application performance.

CPUs

In an OpenVMS Galaxy computing environment, CPUs can be reassigned between instances.

I/O

An OpenVMS Galaxy has a highly scalable I/O subsystem because there are multiple, primary CPUs in the system—one for each instance. Also, OpenVMS currently has features to distribute some I/O to secondary CPUs in an SMP system.

Independent instances

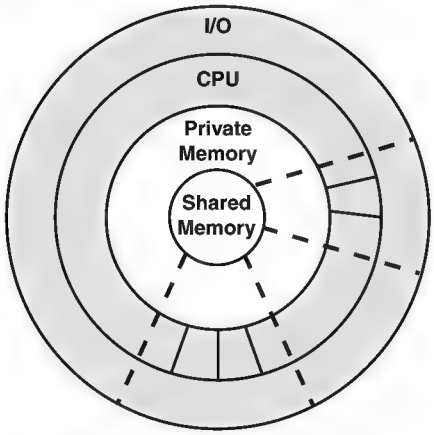
One or more OpenVMS instances can execute without sharing any resources in an OpenVMS Galaxy. An OpenVMS instance that does not share resources is called an **independent instance**.

An independent instance of OpenVMS does not participate in shared memory use. Neither the base operating system nor its applications access shared memory.

An OpenVMS Galaxy can consist solely of independent instances; such a system would resemble traditional mainframe-style partitioning. Architecturally, OpenVMS Galaxy is based on a symmetric multiprocessor (SMP) hardware architecture. It assumes that CPUs, memory, and I/O have full connectivity within the machine and that the memory is cache coherent. Each subsystem has full access to all other subsystems.

As shown in Figure 2-1, Galaxy software looks at the resources as if they were a pie. The various resources (CPUs, private memory, shared memory, and I/O) are arranged as concentric bands within the pie in a specific hierarchy. Shared memory is at the center.

Figure 2-1 OpenVMS Galaxy Architecture Diagram

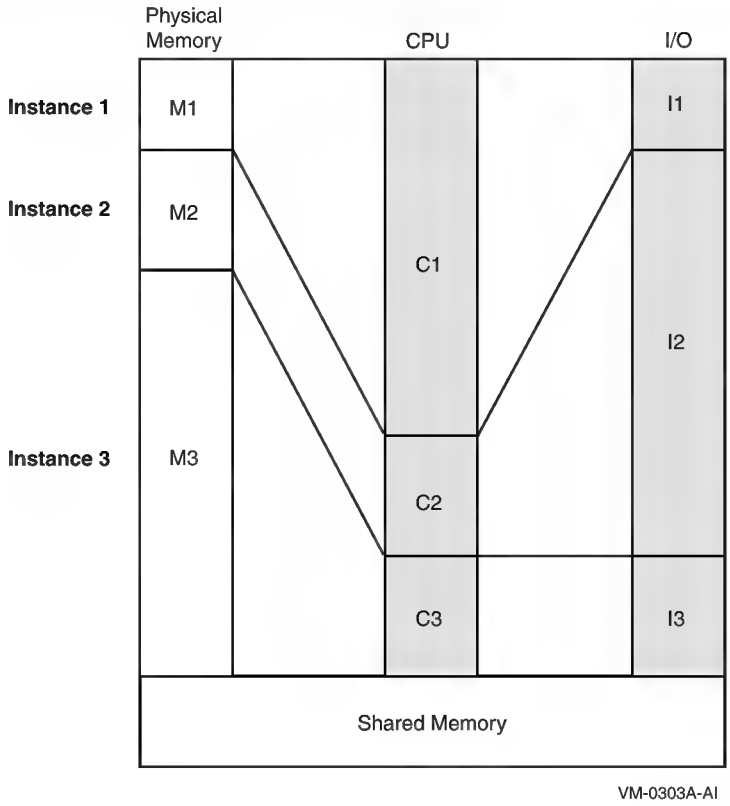


Galaxy supports the ability to divide the pie into multiple slices, each of disparate size. Each slice, regardless of size, has access to all of shared memory. Furthermore, because software partitions the pie, you can dynamically vary the number and size of slices.

In summary, each slice of the pie is a separate and complete instance of the operating system. Each instance has some amount of dedicated private memory, a number of CPUs, and the necessary I/O. Each instance can see all of shared memory, which is where the application data resides. System resources can be reassigned between the instances of the operating system without rebooting.

For example, Figure 2-2 illustrates how Galaxy proportions can differ between instances.

Figure 2-2 Another Galaxy Architecture Diagram



OpenVMS Galaxy Features

An evolution in OpenVMS functionality, OpenVMS Galaxy leverages proven OpenVMS Cluster, symmetric multiprocessing, and performance capabilities to offer greater levels of performance, scalability, and availability with extremely flexible operational capabilities.

Clustering

Fifteen years of proven OpenVMS Cluster technology facilitates communication among clustered instances within an OpenVMS Galaxy.

An OpenVMS cluster is a software concept. It is a set of coordinated OpenVMS operating systems, one per computer, communicating over various media to combine the processing power and storage capacity of multiple computers into a single, shared-everything environment.

An OpenVMS Galaxy is also a software concept. However, it is a set of coordinated OpenVMS operating systems, in a single computer, communicating through shared memory. An instance of the operating system in an OpenVMS Galaxy can be clustered with other instances within the Galaxy or with instances in other systems.

An OpenVMS Galaxy is a complete system in and of itself. Although an OpenVMS Galaxy can be added to an existing OpenVMS cluster in the same way that nodes can be added to a cluster today, the focus of the OpenVMS Galaxy architecture is the single system. An application running totally within an OpenVMS Galaxy can take advantage of performance opportunities not present in multisystem clusters.

SMP

Any instance in an OpenVMS Galaxy can be an SMP configuration. The number of CPUs is part of the definition of an instance. Because an instance in the OpenVMS Galaxy is a complete OpenVMS operating system, all applications behave the same as they would on a traditional, single-instance computer.

CPU reassignment

A CPU can be dynamically reassigned from one instance to another while all applications on both instances continue to run. Reassignment is realized by three separate functions: stopping, reassigning, and starting the CPU in question. As resource needs of applications change, the CPUs can be reassigned to the appropriate instances. There are some restrictions; for example, the primary CPU in an instance cannot be reassigned, and a CPU cannot specifically be designated to handle certain interrupts.

Dynamic reconfiguration

Multiple instances of the OpenVMS operating system allow system managers to reassign processing power to the instances whose applications most need it. As that need varies over time, so can the configuration. OpenVMS allows dynamic reconfiguration while all instances and their applications continue to run.

OpenVMS Galaxy Benefits

Many of the benefits of OpenVMS Galaxy technology result directly from running multiple instances of the OpenVMS operating system in a single computer.

With several instances of OpenVMS in memory at the same time, an OpenVMS Galaxy computing environment gives you improvements in:

- Compatibility—Existing applications run without changes.
- Availability—Presents opportunities to upgrade software and expand system capacity without down time.
- Scalability—Offers scaling alternatives that improve performance of SMP and cluster environments.
- Adaptability—Physical resources can be dynamically reassigned to meet changing workload demands.
- Cost of ownership—Fewer computer systems reduce system management requirements, floor space, and more.
- Performance—Eliminates many bottlenecks and provides more I/O configuration possibilities.

The following descriptions provide more details about these benefits.

Compatibility

Existing single-system applications run without changes on instances in an OpenVMS Galaxy. Existing OpenVMS cluster applications also run without changes on clustered instances in an OpenVMS Galaxy.

Availability

An OpenVMS Galaxy system is more available than a traditional, single-system-view, SMP system because multiple instances of the operating system control hardware resources.

OpenVMS Galaxy allows you to run different versions of OpenVMS (Version 7.2 and later) simultaneously. For example, you can test a new version of the operating system or an application in one instance while continuing to run the current version in the other instances. You can then upgrade your entire system, one instance at a time.

Scalability

System managers can assign resources to match application requirements as business needs grow or change. When a CPU is added to a Galaxy configuration, it can be assigned to any instance of OpenVMS. This means that applications can realize 100 percent of a CPU's power.

Typical SMP scaling issues do not restrict an OpenVMS Galaxy. System managers can define the number of OpenVMS instances, assign the number of CPUs in each instance, and control how they are used.

Additionally, a trial-and-error method of evaluating resources is a viable strategy. System managers can reassign CPUs among instances of OpenVMS until the most effective combination of resources is found. All instances of OpenVMS and their applications continue to run while CPUs are reassigned.

Adaptability

An OpenVMS Galaxy is highly adaptable because computing resources can be dynamically reassigned to other instances of the operating system while all applications continue to run.

Reassigning CPUs best demonstrates the adaptive capability of an OpenVMS Galaxy computing environment. For example, if a system manager knows that resource demands change at certain times, the system manager can write a command procedure to reassign CPUs to other instances of OpenVMS and submit the procedure to a batch queue. The same could be done to manage system load characteristics.

In an OpenVMS Galaxy environment, software is in total control of assigning and dynamically reassigning hardware resources. As additional hardware is added to an OpenVMS Galaxy system, resources can be added to existing instances, or new instances can be defined without affecting running applications.

Cost of ownership

An OpenVMS Galaxy presents opportunities to upgrade existing computers and expand their capacity, or to replace some number of computers, whether they are cluster members or independent systems, with a single computer running multiple instances of the operating system. Fewer computers greatly reduces system management requirements as well as floor space.

Performance

An OpenVMS Galaxy can provide high commercial application performance by eliminating many SMP and cluster-scaling bottlenecks. Also, the distribution of interrupts across instances provides many I/O configuration possibilities; for example, a system's I/O workload can be partitioned so that certain I/O traffic is done on specific instances.

OpenVMS Galaxy Version 7.3 Features

With OpenVMS Alpha Version 7.3, you can create an OpenVMS Galaxy environment that allows you to:

- Run eight instances on an AlphaServer GS320 or a GS1280/32.
- Run four instances on an AlphaServer GS160, an ES80 or a GS1280/16.
- Run two instances on an AlphaServer GS160, an ES47 or a GS1280/8.
- Run three instances of OpenVMS on AlphaServer GS140 or 8400 systems.

- Run two instances of OpenVMS on AlphaServer GS60, GS60E, GS80, 8200, 4100, or ES40 systems.
- Reassign CPUs between instances.
- Perform independent booting and shutdown of instances.
- Use shared memory for communication between instances.
- Cluster instances within an OpenVMS Galaxy using the shared memory cluster interconnect.
- Cluster instances with non-Galaxy systems.
- Create applications using OpenVMS Galaxy APIs for resource management, event notification, locking for synchronization, and shared memory for global sections.
- Use the Galaxy Configuration Utility (GCU) to view and control the OpenVMS Galaxy environment. (See Chapter 13 for more information.)
- Run a single-instance OpenVMS Galaxy on an Alpha system for application development.

OpenVMS Galaxy Advantages

OpenVMS Galaxy offers you several technical advantages if you are looking to improve your ability to manage unpredictable, variable, or growing IT workloads. OpenVMS Galaxy technology provides the most flexible way to dynamically reconfigure and manage system resources. An integrated hardware and software solution, OpenVMS Galaxy allows system managers to perform tasks such as reassigning individual CPUs through a simple drag and drop procedure.

An OpenVMS Galaxy computing environment is ideal for high-availability applications, such as:

- Database servers
- Transaction processing systems
- Data warehousing
- Data mining
- Internet servers
- NonStop eBusiness solutions

An OpenVMS Galaxy computing environment is also a natural evolution for current OpenVMS users with clusters or multiple sparsely configured systems.

An OpenVMS Galaxy is attractive for growing organizations with varying workloads—predictable or unpredictable.

When OpenVMS Galaxy Is Not the Best Choice

Even though OpenVMS Galaxy technology provides the most flexible way to dynamically reconfigure and manage system resources, there are times when a Galaxy system is not the best technical choice for an organization. OpenVMS Galaxy is not the best choice if your computing needs are focused on any of the following:

- Single stream nonthreaded computation.
- Situations where individual CPUs must be physically separate to be near other equipment, such as for process control.
- If traditional SMP will not work.

Possible OpenVMS Galaxy Configurations

An OpenVMS Galaxy computing environment lets customers decide how much cooperation exists between instances in a single computer system.

In a **shared-nothing** computing model, the instances do not share any resources; operations are isolated from one another (see the Section "Shared-Nothing Computing Model" on page 39).

In a **shared-partial** computing model, the instances share some resources and cooperate in a limited way (see the Section "Shared-Partial Computing Model" on page 39).

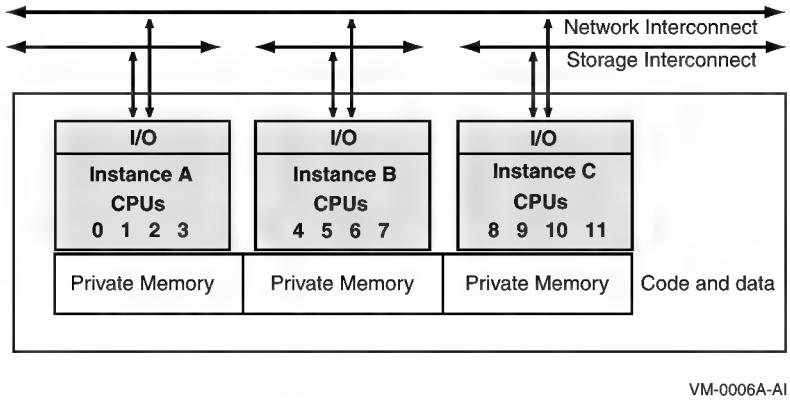
In a **shared-everything** model, the instances cooperate fully and share all available resources, to the point where the operating system presents a single cohesive entity to the network (see the Section "Shared-Everything Computing Model" on page 40).

Shared-Nothing Computing Model

In a shared-nothing configuration (shown in Figure 2-3), the instances of OpenVMS are completely independent of each other and are connected through external interconnects, as though they were separate computers.

With Galaxy, all available memory is allocated into private memory for each instance of OpenVMS. Each instance has its own set of CPUs and an appropriate amount of I/O resources assigned to it.

Figure 2-3 Shared-Nothing Computing Model

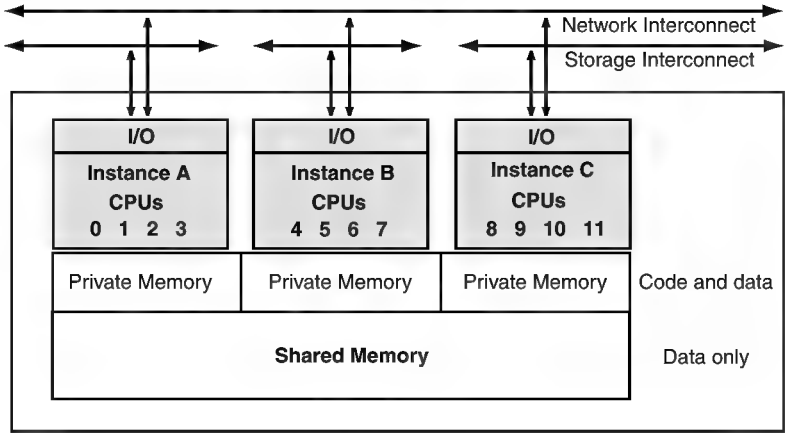


Shared-Partial Computing Model

In a shared-partial configuration (shown in Figure 2-4), a portion of system memory is designated as shared memory, which each instance can access. Code and data for each instance are contained in private memory. Data that is shared by applications in several instances is stored in shared memory.

The instances are not clustered.

Figure 2-4 Shared-Partial Computing Model



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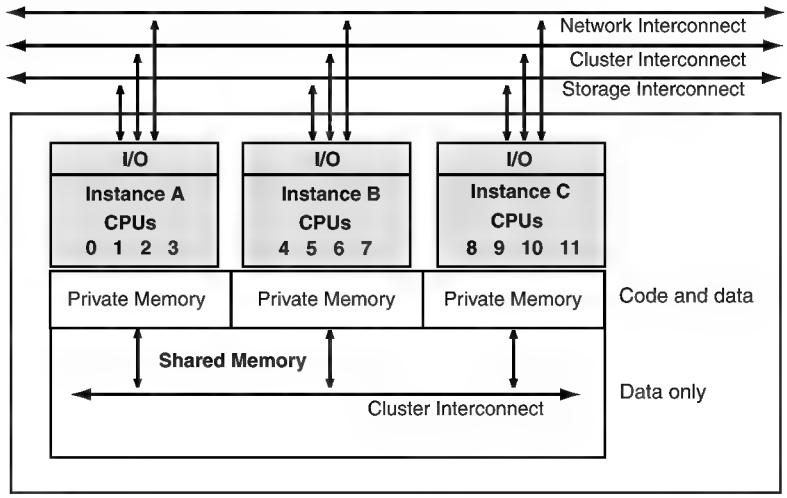
Shared-Everything Computing Model

In a shared-everything configuration (shown in Figure 2-5), the instances share memory and are clustered with one another.

Figure 2-5 Shared-Everything Computing Model



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A Single-Instance Galaxy Configuration

A **single-instance Galaxy** is a system without a Galaxy console. Galaxy configuration data, which is normally provided by console firmware, is instead created in a file. By setting the system parameter GALAXY to 1, SYSBOOT reads the file into memory and the system boots as a single-instance Galaxy, complete with shared memory, Galaxy system services, and even self-migration of CPUs. This can be done on any Alpha platform, except for the ES45.

Single-instance Galaxy configurations run on everything from laptops to mainframes. This capability allows early adopters to evaluate OpenVMS Galaxy features, and most importantly, to develop and test Galaxy-aware applications without incurring the expense of setting up a full-scale Galaxy platform.

Because the single-instance Galaxy is not an emulator—it is real Galaxy code—applications run on multiple-instance configurations.

For more information about running a single-instance Galaxy, see Chapter 11.

OpenVMS Galaxy Configuration Considerations

When you plan to create an OpenVMS Galaxy computing environment, you need to make sure that you have the appropriate hardware for your configuration. General OpenVMS Galaxy configuration rules include:

- One or more CPUs per instance.
- One or more I/O modules per instance.
- Dedicated serial console port or network access per instance.
- Memory:
  - — Enough private memory for OpenVMS and applications
  - — Enough shared memory for the shared memory cluster interconnect, global sections, and so on
- Display for configuration management with either an Alpha or VAX workstation running DECwindows or a Windows NT workstation with an X terminal emulator.

For more information about hardware-specific configuration requirements, see the chapter in this book specific to your hardware.

XMI Bus Support

The XMI bus is supported only on the first instance (instance 0) of a Galaxy configuration in an AlphaServer 8400 system.

Only one DWLM-AA XMI plug-in-unit subsystem cage for all XMI devices is supported on an AlphaServer 8400 system. The DWLM-AA takes up quite a bit of space in the system because an I/O bulkhead is required on the back of the system to connect all XMI devices to the system. This allows only two additional DWLPB PCI plug-in units in the system.

Memory Granularity Restrictions

Note the following memory granularity restrictions:

- Private memory must start on a 64 MB boundary.
- Shared memory must start on an 8 MB boundary.
- All instances except the last must have a multiple of 64 MB of memory.

Incorrectly configured memory usually wastes memory.

EISA Bus Support

The EISA bus is supported only on the first instance (instance 0) of a Galaxy configuration. Due to the design of all EISA options, they must always be on instance 0 of the system. A KFE70 must be used in the first instance for any EISA devices in the Galaxy system.

All EISA devices must be on instance 0. No EISA devices are supported on any other instance in a Galaxy system.

A KFE72-DA installed in other instances provides console connection only and cannot be used for other EISA devices.

CD Drive Recommendation

HP recommends that a CD drive be available for each instance in an OpenVMS Galaxy computing environment. If you plan to use multiple system disks in your OpenVMS Galaxy, a CD drive per instance is helpful for upgrades and software installations.

If your OpenVMS Galaxy instances are clustered together and use a single common system disk, a single CD drive may be sufficient because the CD drive can be served to the other clustered instances. For operating system upgrades, the instance with the attached CD drive can be used to perform the upgrade.

Clustering with Galaxy

This section contains information on clustering instances with other instances in an OpenVMS Galaxy computing environment or with non-Galaxy OpenVMS clusters.

For information about OpenVMS Galaxy licensing requirements that apply to clustering instances, see the *OpenVMS License Management Utility Manual*.

Becoming an OpenVMS Galaxy Instance

When you are installing OpenVMS Alpha Version 7.3, the OpenVMS installation dialog asks questions about OpenVMS Cluster and OpenVMS Galaxy instances.

If you answered "Yes" to the question

```
Will this system be a member of an OpenVMS cluster? (Yes/No)
```

and you answered "Yes" to the question

```
Will this system be an instance in an OpenVMS Galaxy? (Yes/No)
```

the following information is displayed:

```
For compatibility with an OpenVMS Galaxy, any systems in the OpenVMS
cluster which are running versions of OpenVMS prior to V7.1-2 must
have a remedial kit installed. The appropriate kit from the following
list must be installed on all system disks used by these systems.
(Later versions of these remedial kits may be used if available.)

        Alpha V7.1 and V7.1-1xx         ALPSYSB02_071
        Alpha V6.2 and V6.2-1xx         ALPSYSB02_062

        VAX V7.1                        VAXSYSB01_071
        VAX V6.2                        VAXSYSB01_062
```

For more information, see the *HP OpenVMS Alpha Version 7.3-2 Upgrade and Installation Manual.*

SCSI Cluster Considerations

This section summarizes information about SCSI device naming for OpenVMS Galaxy computing environments. For more complete information about OpenVMS Cluster device naming, see the *OpenVMS Cluster Systems* manual.

If you are creating an OpenVMS Galaxy with shared SCSI buses, you must note the following:

For OpenVMS to give the SCSI devices the same name on each instance correctly, you need to use the device-naming feature of OpenVMS.

For example, assume that you have the following adapters on your system when you enter the SHOW CONFIG command:

```
PKA0 (embedded SCSI for CDROM)
PKB0 (UltraSCSI controller KZPxxx)
PKC0 (UltraSCSI controller)
```

When you make this system a two-instance Galaxy, your hardware looks like the following:

```
Instance 0
PKA0  (UltraSCSI controller)

Instance 1
PKA0  (embedded SCSI for CDROM)
PKB0  (UltraSCSI controller)
```

Your shared SCSI is connected from PKA0 on instance 0 to PKB0 on instance 1.

If you initialize the system with the LP_COUNT environment variable set to 0, you will not be able to boot OpenVMS on the system unless the SYSGEN parameter STARTUP_P1 is set to MINIMUM.

This is because, with the LP_COUNT variable set to 0, you now have PKB connected to PKC, and the SCSI device-naming that was set up for initializing with multiple partitions is not correct for initializing with the LP_COUNT variable set to 0.

During the device configuration that occurs during boot, OpenVMS notices that PKA0 and PKB0 are connected together. OpenVMS expects that each device has the same allocation class and names, but in this case, they do not.

The device naming that was set up for the two-instance Galaxy does not function correctly because the console naming of the controllers has changed.

Security Considerations in an OpenVMS Galaxy Computing Environment

OpenVMS Galaxy instances executing in a shared-everything cluster environment, in which all security database files are shared among all instances, automatically provide a consistent view of all Galaxy-related security profiles.

If you choose not to share all security database files throughout all Galaxy instances, a consistent security profile can only be achieved manually. Changes to an object's security profile must be followed by similar changes on all instances where this object can be accessed.

Because of the need to propagate changes manually, it is unlikely that such a configuration would ever be covered by a US C2 evaluation or by similar evaluations from other authorities. Organizations that require operating systems to have security evaluations should ensure that all instances in a single OpenVMS Galaxy belong to the same cluster.

Configuring OpenVMS Galaxy Instances in Time Zones

OpenVMS Galaxy instances do not have to be in the same time zone unless they are in the same cluster. For example, each instance in a three-instance Galaxy configuration could be in a different time zone.

Developing OpenVMS Galaxy Programs

The following sections describe OpenVMS programming interfaces that are useful in developing OpenVMS Galaxy application programs. Many of the concepts are extensions of the traditional single-instance OpenVMS system.

To see the C function prototypes for the services described in these chapters, enter the following command:

```
$ LIBRARY/EXTRACT=STARLET SYS$LIBRARY:SYS$STARLET_C.TLB/OUTPUT=FILENAME
```

Then search the output file for the service you want to see.

Locking Programming Interfaces

One of the major features of the Galaxy platform is the ability to share resources across multiple instances of the operating system. The services described in this chapter provide primitives upon which a cooperative scheme can be created to synchronize access to shared resources within a Galaxy.

A Galaxy lock is a combination of a spinlock and a mutex. While attempting to acquire an owned Galaxy lock, the thread spins for a short period. If the lock does not become available during the spin, the thread puts itself into a wait state. This is different from SMP spinlocks in which the system crashes if the spin times out, behavior that is not acceptable in a Galaxy.

Given the nature of Galaxy locks, they reside in shared memory. That shared memory can be allocated either by the user or by the Galaxy locking services. If the user allocates the memory, the locking services track only the location of the locks. If the locking services allocate the memory, it is managed on behalf of the user.

Unlike other monitoring code which is only part of the MON version of execlets, the Galaxy lock monitoring code is always loaded.

There are several routines provided to manipulate Galaxy locks. The routines do not provide anything but the basics when it comes to locking. They are a little richer than the spinlocks used to support SMP, but far less than what the lock manager provides. Table 2-1 summarizes the OpenVMS Galaxy system services for lock programming. Syntax for the services in Table 2-1 and Table 2-2 can be found in the *HP OpenVMS System Services Reference Manual*.

Table 2-1 Galaxy System Services for Lock Programming

System Service	Description
$ACQUIRE_GALAXY_LOCK	Acquires ownership of an OpenVMS Galaxy lock.
$CREATE_GALAXY_LOCK	Allocates an OpenVMS Galaxy lock block from a lock table created with the $CREATE_GALAXY_LOCK service.
$CREATE_GALAXY_LOCK_TABLE	Allocates an OpenVMS Galaxy lock table.
$DELETE_GALAXY_LOCK	Invalidates an OpenVMS Galaxy lock and deletes it.
$DELETE_GALAXY_LOCK_TABLE	Deletes an OpenVMS Galaxy lock table.
$GET_GALAXY_LOCK_INFO	Returns certain fields from the specified lock.
$GET_GALAXY_LOCK_SIZE	Returns the minimum and maximum size of an OpenVMS Galaxy lock.
$RELEASE_GALAXY_LOCK	Releases ownership of an OpenVMS Galaxy lock.

System Events Programming Interfaces

Applications can register to be notified when certain system events occur; for example, when an instance joins the Galaxy or if a CPU joins a configure set. (A configure set is a membership of processors that are actively owned and controlled by the current instance.) If events are registered, an application can decide how to respond when the registered events occur.

Table 2-2 summarizes the OpenVMS system services available for events programming.

Table 2-2 Galaxy System Services for Events Programming

System Service	Description
$CLEAR_SYSTEM_EVENT	Removes one or more notification requests previously established by a call to $SET_SYSTEM_EVENT.
$SET_SYSTEM_EVENT	Establishes a request for notification when an OpenVMS system event occurs.

Using SDA in an OpenVMS Galaxy

This section describes SDA information that is specific to an OpenVMS Galaxy computing environment.

For more information about using SDA, see the *OpenVMS Alpha System Analysis Tools Manual*.

Dumping Shared Memory

When a system crash occurs in a Galaxy instance, the default behavior of OpenVMS is to dump the contents of private memory of the failed instance and the contents of shared memory. In a full dump, every page of both shared and private memory is dumped; in a selective dump, only those pages in use at the time of the system crash are dumped.

Dumping of shared memory can be disabled by setting bit 4 of the dynamic SYSGEN parameter DUMPSTYLE. This bit should only be set after consulting your HP support representative, as the resulting system dump may not contain the data required to determine the cause of the system crash.

Table 2-3 shows the definitions of all the bits in DUMPSTYLE and their meanings in OpenVMS Alpha. Bits can be combined in any combination.

Table 2-3 Definitions of Bits in DUMPSTYLE

Bit	Value	Description
0	1	0 = Full dump. The entire contents of physical memory are written to the dump file. 1 = Selective dump. The contents of memory are written to the dump file selectively to maximize the usefulness of the dump file while conserving disk space. (Only pages that are in use are written).
1	2	0 = Minimal console output. This consists of the bugcheck code; the identity of the CPU, process, and image where the crash occurred; the system date and time; plus a series of dots indicating progress writing the dump. 1 = Full console output. This includes the minimal output described above plus stack and register contents, system layout, and additional progress information such as the names of processes as they are dumped.
2	4	0 = Dump to system disk. The dumps are written to SYS$SYSDEVICE:[SYSn.SYSEXE]SYSDUMP.DMP, or in its absence, SYS$SYSDEVICE:[SYSn.SYSEXE]PAGEFILE.SYS.1 = Dump to alternate disk. The dumps are written to dump_dev:[SYSn.SYSEXE]SYSDUMP.DMP, where dump_dev is the value of the console environment variable DUMP_DEV.
3	8	0 = Uncompressed dump. Pages are written directly to the dump file. 1 = Compressed dump. Each page is compressed before it is written, providing a saving in space and in the time taken to write the dump, at the expense of a slight increase in time taken to access the dump.
4	16	0 = Dump shared memory. 1 = Do not dump shared memory.

The default setting for DUMPSTYLE is 0 (an uncompressed full dump, including shared memory, written to the system disk). Unless a value for DUMPSTYLE is specified in MODPARAMS.DAT, AUTOGEN.COM sets DUMPSTYLE to 1 (an uncompressed selective dump, including shared memory, written to the system disk) if there are less than 128 MB of memory on the system, or to 9 (a compressed selective dump, including shared memory, written to the system disk) otherwise.

Summary of SDA Command Interface Changes or Additions

Table 2-4 summarizes enhancements to the System Dump Analyzer to view shared memory and OpenVMS Galaxy data structures. For more details, see the appropriate commands.

Table 2-4 SDA Command Enhancements

Command	Description
SHOW SHM_CPP	The default is a brief display of all SHM_CPPs.
VALIDATE SHM_CPP	The default action is to validate all SHM_CPPs and the counts and ranges of attached PFNs, but not the contents of the database for each PFN.
SHOW SHM_REG	The default is a brief display of all SHM_REGs.
/GLXSYS and /GLXGRP to SHOW GSD	Displays Galaxy data structures.
SHOW GMDB	Displays the contents of the GMDB and NODEB blocks. The default is a detailed display of GMDB.
SHOW GALAXY	Shows a brief display of GMDB and all node blocks.
SHOW GLOCK	Displays Galaxy lock structures. The default is a display of base GLOCK structures.
SHOW GCT	Displays Galaxy configuration tree. The default is /SUMMARY.
SHOW PAGE_TABLE and SHOW PROCESS/PAGE_TABLE	Shows page and process page tables.

3 NUMA Implications on OpenVMS Applications

NUMA (nonuniform memory access) is an attribute of a system in which access time to any given physical memory location is not the same for all CPUs. Given this architecture, you must have consistently good location (but not necessarily 100 percent of the time) for high performance.

The operating system treats the hardware as a set of resource affinity domains (RADs). A RAD is the software grouping of physical resources (CPUs, memory, and I/O) with common access characteristics. On the AlphaServer GS80/160/320 systems, a RAD corresponds to a quad building block (QBB); on AlphaServer ES47/ES80/GS1280 systems, a RAD corresponds to a two-processor CPU board. CPUs access memory in their own RAD faster than they access memory in another RAD.

If OpenVMS is running on the resources of a single RAD, then there is no NUMA effect and this discussion does not apply. Whenever possible and practical, you can benefit by running in a single RAD, which eliminates the complexities NUMA may present.

The most common question for overall system performance in a NUMA environment is, “uniform for all?” or “optimal for a few?” In other words, do you want all processes to have roughly equivalent performance, or do you want to focus on some specific processes and make them as efficient as possible? Whenever a single instance of OpenVMS runs on multiple RADs (whether it is the entire machine, a hard partition, or a Galaxy instance), then you must answer this question, because the answer dictates a number of configuration and management decisions you need to understand.

The OpenVMS default NUMA mode of operation is "uniform for all." Resources are assigned so that over time each process on the system has, on average, roughly the same performance potential.

If "uniform for all" is not what you want, you must understand the interfaces available to you in order to achieve the more specialized "optimal for a few" or "dedicated" environment. Processes and data can be assigned to specific resources to give them the highest performance potential possible.

To further enhance your understanding of the NUMA environment, this chapter discusses the following topics:

- Base operating system NUMA actions
- Application resource considerations
- APIs

OpenVMS NUMA Awareness

OpenVMS memory management and process scheduling have been enhanced to work more efficiently on the AlphaServer GS series systems hardware.

Each of the following areas of enhancement adds a new capability to the system. Individually each brings increased performance potential for certain application needs. Collectively they provide the environment necessary for a diverse application mix. The areas being addressed are:

- Assignment of process private pages

- Assignment of reserved memory pages
- Process scheduling
- Replication of read-only system space pages
- Allocation of nonpaged pool
- Tools for observing page assignment

A CPU references memory in the same RAD three times faster than it references memory in another RAD. Therefore, it is important to keep the code being executed and the memory being referenced in the same RAD as much as possible. Consistently good location is the key to good performance. In assessing performance, the following questions illustrate the types of issues a programmer needs to consider:

- Where is the code you are executing?
- Where is the data you are accessing?
- Where is the I/O device you are using?

The OpenVMS scheduler and the memory management subsystem work together to achieve the best possible location by:

- Assigning each process a preferred or home RAD.
- Usually scheduling a process on a CPU in its home RAD.
- Replicating operating system read-only code and some data in each RAD.
- Distributing global pages over RADs.
- Striping reserved memory over RADs.

Home RAD

The OpenVMS operating system assigns a home RAD to each process during process creation. This has two major implications. First, with rare exception, one of the CPUs in the process's home RAD runs the process. Second, all process private pages required by the process comes from memory in the home RAD. This combination aids in maximizing local memory references.

When assigning home RADs, the default action of OpenVMS is to distribute the processes over the RADs.

System Code Replication

During system startup, the operating system code is replicated in the memory of each RAD so that each process in the system accesses local memory whenever it requires system functions. This replication is of both the executive code and the installed resident image code granularity hint regions.

Distributing Global Pages

The default action of OpenVMS is to distribute global pages (the pages of a global section) over the RADs. This approach is also taken with the assignment of global pages that have been declared as reserved memory during system startup.

Application Resource Considerations

Each application environment is different. An application's structure may dictate which options are best for achieving the desired goals. Some of the deciding factors include:

- Number of processes
- Amount of memory needed
- Amount of sharing between processes
- Use of certain base operating system features
- Use of locks and their location

There are few absolute rules, but the following sections present some basic concepts and examples that usually lead to the best outcome. Localizing (on-RAD) memory access is always the goal, but it is not always achievable and that is where tradeoffs are most likely to be made.

Processes and Shared Data

If you have hundreds, or perhaps thousands, of processes that access a single global section, then you probably want the default behavior of the operating system. The pages of the global section are equally distributed in the memory of all RADs, and the processes' home RAD assignments are equally distributed over the CPUs. This is the distributed, or "uniform," effect where over time all processes have similar performance potential given random accesses to the global section. None are optimal but none are at a severe disadvantage compared to the others.

On the other hand, a small number of processes accessing a global section can be located in a single RAD as long as four CPUs can handle the processing load and a single RAD contains sufficient memory for the entire global section. This localizes most memory access, enhancing the performance of those specifically located processes. This strategy can be employed multiple times on the same system by locating one set of processes and their data in one RAD and a second set of processes and their data in another RAD.

Memory

AlphaServer GS Series systems have the potential for large amounts of memory. Take advantage of the large memory capacity whenever possible. For example, consider duplicating code or data in multiple RADs. It takes analysis, may seem wasteful of space, and requires coordination. However, it may be worthwhile if it ultimately makes significantly more memory references local.

Consider using a RAM disk product. Even if NUMA is involved, in-memory references outperform real device I/O.

Sharing and Synchronization

Sharing data usually requires synchronization. If the coordination mechanism is a single memory location (sometimes called a latch, a lock, or a semaphore), then it may be the cause of many remote accesses and therefore degrade performance if the contention is high enough. Multiple levels of such locks distributed throughout the data may reduce the amount of remote access.

Use of OpenVMS Features

Heavy use of certain base operating system features will result in much remote access because the data to support these functions resides in the memory of RAD0.

Batch Job Support for NUMA Resource Affinity Domains

This section describes updates to the OpenVMS batch processing subsystem in support of resource affinity domains (RADs) in a NUMA environment.

System managers can assign batch queues to specific support of resource affinity domains (RADs) in a NUMA environment, and users can specify a RAD on which to run a batch job.

These new features are restricted for use on batch execution queues and batch jobs.

See the *HP OpenVMS DCL Dictionary* for DCL command information.

Batch Queue Level RAD Support

A new qualifier, /RAD, is available to the following DCL commands: INITIALIZE/QUEUE, SET/QUEUE, and START/QUEUE. The system manager specifies the RAD number on which to run batch jobs assigned to the queue.

The RAD value is validated as a positive integer between 0 and SYI$_RAD_MAX_RADS. The SHOW/QUEUE/FULL command now displays the RAD in its output, and the F$GETQUI lexical function now accepts a new RAD item.

Examples

This section describes a sequence of the commands and their effects on a batch queue. A SHOW command is included in each example to illustrate the batch queue modifications.

- The following INITIALIZE/QUEUE command creates or reinitializes the batch queue BATCHQ1 to run on node QUEBIT. All jobs assigned to this queue will run on RAD 0.

```
$ INITIALIZE/QUEUE/ON=QUEBIT::/BATCH/RAD=0   BATCHQ1

$ SHOW QUEUE/FULL BATCHQ1
Batch queue BATCHQ1, stopped, QUEBIT::
 /BASE_PRIORITY=4 /JOB_LIMIT=1 /OWNER=[SYSTEM]
 /PROTECTION=(S:M,O:D,G:R,W:S) /RAD=0
```

- The following START/QUEUE command modifies BATCHQ1 to run all assigned jobs on RAD 1 of QUEBIT, and readies the queue to accept jobs for processing:

```
$ START/QUEUE/RAD=1 BATCHQ1

$ SHOW QUEUE/FULL BATCHQ1
Batch queue BATCHQ1, idle, on QUEBIT::
  /BASE_PRIORITY=4 /JOB_LIMIT=3 /OWNER=[SYSTEM]
  /PROTECTION=(S:M,O:D,G:R,W:S) /RAD=1
```

- The following SET/QUEUE command modifies the batch queue to run all assigned jobs on RAD 0 of QUEBIT. Any new jobs assigned to the queue will run on RAD 0. Jobs already executing on the queue will continue to completion executing on the previous RAD value.

```
$ SET/QUEUE/RAD=0 BATCHQ1

$ SHOW QUEUE/FULL BATCHQ1
Batch queue BATCHQ1, idle, on QUEBIT::
  /BASE_PRIORITY=4 /JOB_LIMIT=3 /OWNER=[SYSTEM]
  /PROTECTION=(S:M,O:D,G:R,W:S) /RAD=0
```

- To erase the RAD value for a batch queue, use the SET/QUEUE/NORAD command:

```
$ SET/QUEUE/NORAD BATCHQ1

$ SHOW QUEUE/FULL BATCHQ1
Batch queue BATCHQ1, idle, on QUEBIT::
  /BASE_PRIORITY=4 /JOB_LIMIT=3 /OWNER=[SYSTEM]
  /PROTECTION=(S:M,O:D,G:R,W:S)
```

- Use the F$GETQUI lexical function to return the value of the RAD. A value of -1 indicates no RAD value is attributed to the queue:

```
$ WRITE SYS$OUTPUT F$GETQUI("DISPLAY_QUEUE","RAD","BATCHQ1")
 -1
```

Job Level RAD Support

The new qualifier, /RAD, is added to the following DCL commands: SUBMIT and SET/ENTRY.

The user specifies the RAD number on which the submitted batch job is to execute in the qualifier value. The SHOW ENTRY and SHOW QUEUE/FULL commands are enhanced to list the RAD setting on batch jobs.

Examples

When a job is submitted to a batch queue that does not have a RAD setting, the job will execute using the RAD specified on the SUBMIT command.

The following command submits TEST.COM to the queue ANYRADQ. There is no RAD setting on the ANYRADQ queue.

```
$ SUBMIT/HOLD/QUEUE=ANYRADQ /RAD=1  TEST.COM
Job TEST (queue ANYRADQ, entry 23) holding

$ SHOW ENTRY/FULL 23
  Entry  Jobname         Username     Blocks  Status
  -----  -------         --------     ------  ------
     23  TEST            SYSTEM               Holding
         On idle batch queue ANYRADQ
         Submitted 24-JUL-2001 14:19:37.44 /KEEP /NOPRINT /PRIORITY=100
         /RAD=0
         File: _$1$DKB200:[SWEENEY.CLIUTL]TEST.COM;1
```

When a job is submitted to a batch queue that does have a RAD setting, the job will execute using the RAD specified on the queue, regardless of the RAD specified on the SUBMIT command. This behavior is consistent with other batch system features.

The queue, BATCHQ1, is defined with /RAD=0. The following SUBMIT command example creates a job that runs on RAD 0, even though the user specified RAD 1 on the submission:

```
$ SUBMIT/HOLD/QUEUE=BATCHQ1 /RAD=1  TEST.COM
Job TEST (queue BATCHQ1, entry 24) holding

$ SHOW ENTRY 24/FULL
  Entry  Jobname         Username     Blocks  Status
  -----  -------         --------     ------  ------
```

```
24  TEST            SYSTEM               Holding
    On idle batch queue BATCHQ1
    Submitted 24-JUL-2001 14:23:10.37 /KEEP /NOPRINT /PRIORITY=100
    /RAD=0
    File: _$1$DKB200:[SWEENEY.CLIUTL]TEST.COM;2
```

Run-Time Behavior

When you specify a RAD on a batch job, the job controller creates the process with the new HOME_RAD argument set to the RAD value on the job.

If the RAD specified on the job is invalid on the target system, the job controller will output a BADRAD message to the operator console. If the bad RAD value matches the RAD setting on the batch queue, the batch queue is stopped. The job remains in the queue.

Error Processing

The following example shows an error in run-time processing:

```
SYSTEM@QUEBIT> SUBMIT/NONOTIFY/NOLOG/QUEUE=BATCHQ1 TEST.COM
Job TEST (queue BATCHQ1, entry 30) started on BATCHQ1

OPCOM MESSAGES

SYSTEM@QUEBIT> START/QUEUE BATCHQ1
%%%%%%%%%%  OPCOM  25-JUL-2001 16:15:48.52  %%%%%%%%%%
Message from user SYSTEM on QUEBIT
%JBC-E-FAILCREPRC, job controller could not create a process

%%%%%%%%%%  OPCOM  25-JUL-2001 16:15:48.53  %%%%%%%%%%
Message from user SYSTEM on QUEBIT
-SYSTEM-E-BADRAD, bad RAD specified

%%%%%%%%%%  OPCOM  25-JUL-2001 16:15:48.54  %%%%%%%%%%
Message from user SYSTEM on QUEBIT
%QMAN-E-CREPRCSTOP, failed to create a batch process, queue BATCHQ1 will be stopped

$ SYSTEM@QUEBIT> WRITE SYS$OUTPUT  -
_$ F$message(%x'F$GETQUI("DISPLAY_ENTRY","CONDITION_VECTOR","30")')
%SYSTEM-E-BADRAD, bad RAD specified
```

RAD Modifications On Batch Queues

When you change the RAD value on a batch queue, the jobs currently in the batch queue are not dynamically updated with the new RAD value specified on the queue.

Any executing jobs will complete processing using the original RAD value. Jobs in the pending, holding, or timed execution states will retain the old RAD value on the job; however, when such a job becomes executable, the job is updated with the new RAD value and runs on the RAD specified on the queue.

RAD Application Programming Interfaces

A number of interfaces specific to RADs are available to application programmers and system managers to control the location of processes and memory if the system defaults do not meet the needs of the operating environment. The following list provides brief descriptions; the details can be found in the *HP OpenVMS System Services Reference Manual*.

Creating a Process

If you want a process to have a specific home RAD, then use the new HOME_RAD argument in the SYS$CREPRC system service. This allows the application to control the location.

Moving a Process

If a process has already been created and you want to relocate it, use the CAP$M_PURGE_WS_IF_NEW_RAD flag to the SYS$PROCESS_AFFINITY or SYS$PROCESS_CAPABILITY system service. The process's working set will be purged if the choice of affinity or capability results in a change to the home RAD of the process.

Getting Information About a Process

The SYS$GETJPI system service returns the home RAD of a process.

Creating a Global Section

The SYS$CRMPSC_GDZRO_64 and SYS$CREATE_GDZRO system services accept a RAD argument mask. This indicates in which RADs OpenVMS should attempt to assign the pages of the global section.

Assigning Reserved Memory

The SYSMAN interface for assigning reserved memory has a RAD qualifier, so a system manager can declare that the memory being reserved should come from specific RADs.

Getting Information About the System

The SYS$GETSYI system service defines the following item codes for obtaining RAD information:

- RAD_MAX_RADS shows the maximum number of RADs possible on a platform.
- RAD_CPUS shows a longword array of RAD/CPU pairs.
- RAD_MEMSIZE shows a longword array of RAD/page_count pairs.
- RAD_SHMEMSIZE shows a longword array of RAD/page_count pairs.

RAD_SUPPORT System Parameter

The RAD_SUPPORT system parameter has numerous bits and fields defined for customizing individual RAD-related actions. For more information about those bits, see the example in the SHOW RAD section.

RAD System Services Summary Table

The following table describes RAD system service information for OpenVMS Version 7.3 and later.

For more information, see the *OpenVMS System Services Reference Manual*.

System Service	RAD Information
$CREATE_GDZRO	Argument: **rad_mask** Flag: **SEC$M_RAD_HINT** Error status: **SS$_BADRAD**
$CREPRC	Argument: **home_rad** Status flag bit: **stsflg** Symbolic name: **PRC$M_HOME_RAD** Error status: **SS$_BADRAD**
$CRMPSC_GDZRO_64	Argument: **rad_mask** Flag: **SEC$M_RAD_MASK** Error status: **SS$_BADRAD**
$GETJPI	Item code: **JPI$_HOME_RAD**
$GETSYI	Item codes: **RAD_MAX_RADS**, **RAD_CPUS**, **RAD_MEMSIZE**, **RAD_SHMEMSIZE**, **GALAXY_SHMEMSIZE**
$SET_PROCESS_PROPERTIESW	Item code: **PPROP$C_HOME_RAD**

RAD DCL Command Summary Table

The following table summarizes OpenVMS RAD DCL commands. For more information, see the *HP OpenVMS DCL Dictionary*.

DCL Command/Lexical	RAD Information
SET PROCESS	Qualifier: **/RAD=HOME=n**
SHOW PROCESS	Qualifier: **/RAD**
F$GETJPI	Item code: **HOME_RAD**
F$GETSYI	Item codes: **RAD_MAX_RADS**, **RAD_CPUS**, **RAD_MEMSIZE**, **RAD_SHMEMSIZE**

System Dump Analyzer (SDA) Support for RADs

The following System Dump Analyzer (SDA) commands have been enhanced to include RAD support:

- SHOW RAD
- SHOW RMD (reserved memory descriptor)

- SHOW PFN

SHOW RAD

The SDA command SHOW RAD displays:

- Settings and explanations of the RAD_SUPPORT system parameter fields
- Assignment of CPUs and memory to the RADs

This command is useful only on hardware platforms that support RADs (for example, AlphaServer GS160 systems). By default, the SHOW RAD command displays the settings of the RAD_SUPPORT system parameter fields.

Format:

```
SHOW RAD [number|/ALL]
```

Parameter:

number

Displays information on CPUs and memory for the specified RAD.

Qualifier:

/ALL

Displays settings of the RAD_SUPPORT parameter fields and all CPU/memory assignments.

The following example shows the settings of the RAD_SUPPORT system parameter fields:

```
SDA> SHOW RAD

Resource Affinity Domains
-------------------------
RAD information header address: FFFFFFFF.82C2F940
Maximum RAD count:                      00000008
RAD containing SYS$BASE_IMAGE:          00000000
RAD support flags:                      0000000F

3         2 2         1 1
1         4 3         6 5         8 7         0
+-----------+-----------+-----------+-----------+
|..|..| skip|ss|gg|ww|pp|..|..|..|..|..|fs|cr|ae|
+-----------+-----------+-----------+-----------+
|..|..|    0| 0| 0| 0| 0|..|..|..|..|..|00|11|11|
+-----------+-----------+-----------+-----------+

Bit 0 = 1:          RAD support is enabled

Bit 1 = 1:          Soft RAD affinity support is enabled
                    (Default scheduler skip count of 16 attempts)

Bit 2 = 1:          System-space replication support is enabled

Bit 3 = 1:          Copy on soft fault is enabled

Bit 4 = 0:          Default RAD-based page allocation in use

                    Allocation Type              RAD choice
                    ---------------              ----------
                    Process-private pagefault    Home
                    Process creation or inswap   Random
                    Global pagefault             Random
```

```
                    System-space page allocation  Current

Bit 5 = 0:          RAD debug feature is disabled)
```

The following example shows information about the CPUs and memory for RAD 2:

```
SDA> SHOW RAD 2


Resource Affinity Domain 0002
-----------------------------

CPU sets:

  Active      08 09 10 11
  Configure   08 09 10 11
  Potential   08 09 10 11


PFN ranges:

  Start PFN   End PFN     PFN count   Flags
  ---------   --------    ---------   -----
  01000000    0101FFFF    00020000    000A  OpenVMS Base
  01020000    0103FFFF    00020000    0010  Galaxy_Shared

SYSPTBR:      01003C00)
```

SHOW RMD (Reserved Memory Descriptor)

The SDA command SHOW RMD has been enhanced to indicate the RAD from which reserved memory has been allocated. If a RAD was not specified when the reserved memory was allocated, then SDA displays ANY.

SHOW PFN

The SDA command SHOW PFN has been enhanced to include the /RAD qualifier. It is similar to the existing /COLOR qualifier.

RAD Support for Hard Affinity

The SET PROCESS command has been enhanced to include the /AFFINITY qualifier. The /AFFINITY qualifier allows bits in the kernel thread affinity mask to be set or cleared. The bits in the affinity mask can be set or cleared individually, in groups, or all at once.

The /NOAFFINITY qualifier clears all affinity bits currently set in the current or permanent affinity masks, based on the setting of the /PERMANENT qualifier. Specifying the /AFFINITY qualifier has no direct effect, but merely indicates the target of the operations specified by the following secondary parameters:

- /SET=(*n*[,...])

  Sets the affinity for currently active CPUs defined by the CPU IDs *n*, where *n* has the range of 0 to 31.

- /CLEAR=(*n*[,...])

  Clears the affinity for currently active CPUs defined by the position values *n*, where *n* has the range of 0 to 31.

- /PERMANENT

Performs the operation on the permanent affinity mask as well as the current affinity mask, making the changes valid for the life of the kernel thread. (The default behavior is to affect only the affinity mask for the running image.)

This example shows how to set the affinity bits to active for CPUs 1, 2, 3, and 5:

```
$ SET PROCESS /AFFINITY /PERMANENT /SET = (1,2,3,5)
```

On a system that supports RADs, the set of CPUs to which you affinitize a process should be in the same RAD. For example, on an AlphaServer GS160 with CPUs 0,1,2,3 in RAD 0 and with CPUs 4,5,6,7 in RAD 1, SET = 2,3,4,5 would not be a good choice because half of the time you could be executing off your home RAD.

4 Creating an OpenVMS Galaxy on AlphaServer GS140/GS60/GS60E Systems

OpenVMS Alpha Version 7.3 provides support for OpenVMS Galaxy configurations on AlphaServer GS60, GS60E, and GS140 systems. You can run three instances of OpenVMS on AlphaServer GS140 systems or two instances on AlphaServer GS60/GS60E systems.

Downloading Firmware

To create OpenVMS Galaxy environments on AlphaServer GS60, GS60E, and GS140 systems, you must download the latest version of the V6.2 console firmware from the following location:

```
http://ftp.digital.com/pub/DEC/Alpha/firmware/
```

Creating an OpenVMS Galaxy

When you have the firmware, you can:

- Create an OpenVMS Galaxy computing environment on an AlphaServer GS140 by following the procedures in Chapter 5.
- Create an OpenVMS Galaxy computing environment on AlphaServer GS60 or GS60E systems by following the procedures in Chapter 6.

5 Creating an OpenVMS Galaxy on an AlphaServer 8400 System

This chapter describes the process to create an OpenVMS Galaxy computing environment on an AlphaServer 8400.

Step 1: Choose a Configuration and Determine Hardware Requirements

Quick Summary of an AlphaServer 8400 Galaxy Configuration

9 slots for:

- I/O modules (of type KFTIA or KFTHA)
- Memory modules
- Processor modules (2 CPUs per module)

Console line for each partition:

- Standard UART for first partition
- KFE72-DA for each additional partition

Rules:

- Must have an I/O module per partition.
- Maximum of 3 I/O modules.
- Must have at least one CPU module per partition.

Example Configuration 1

2 partitions, 8 CPUs, 12 GB memory

- 9 slots allocated as follows:
  - — 2 I/O modules
  - — 4 Processor modules (2 CPUs each)
  - — 3 Memory modules (4 GB each)

Example Configuration 2

3 partitions, 8 CPUs, 8 GB memory

- 9 slots allocated as follows:
  - — 3 I/O modules
  - — 4 Processor modules (2 CPUs each)

— 2 Memory modules (4 GB each)

Step 2: Set Up Hardware

When you have acquired the necessary hardware for your configuration, follow the procedures in this section to assemble it.

Overview of KFE72-DA Console Subsystem Hardware

The AlphaServer 8400 provides a standard built-in UART, which is used as the console line for the primary Galaxy instance. The console for each additional instance requires a KFE72-DA console subsystem, which is the set of EISA-bus modules that establishes an additional console port.

Note that the AlphaServer 8400 supports a maximum of three I/O modules. Attempting to configure more than three is unsupported.

Each separate KFE72-DA subsystem must be installed in a separate DWLPB card cage with a hose connecting it to a separate I/O module of type KFTIA or KFTHA.

All KFTIA I/O modules must be installed first, starting at slot 8. Any KFTHA I/O modules must follow the KFTIA modules, using the consecutively lower-numbered slots.

You can use any combination of these two I/O modules as long as you follow this slot assignment rule.

When configuring a console subsystem, the I/O hose connecting the I/O module and DWLPB card cage must be plugged into the lowest hose port. Not just the lowest **available** hose port, but the absolute first hose port; the one closest to the top of the module.

The KFE72-DA contains three EISA modules that provide:

- Two COM ports
- An Ethernet port
- A small speaker and other ports (such as a keyboard and a mouse, which are not used for Galaxy configurations)

Installing the KFE72-DA Modules

For each instance of the OpenVMS operating system after instance zero, you must install the following three modules in the PCI card cage:

- Standard I/O module
- Serial port module
- Connector module

To install these modules, follow the procedures in Slide the PCI Card Cage Out to Attaching the Connectors, which supplement the installation procedures for KFE72-DA modules in Chapter 5 of the *KFE72 Installation Guide*.

Slide the PCI Card Cage Out

Follow the procedures in Section 5.2.1 of the *KFE72 Installation Guide.*

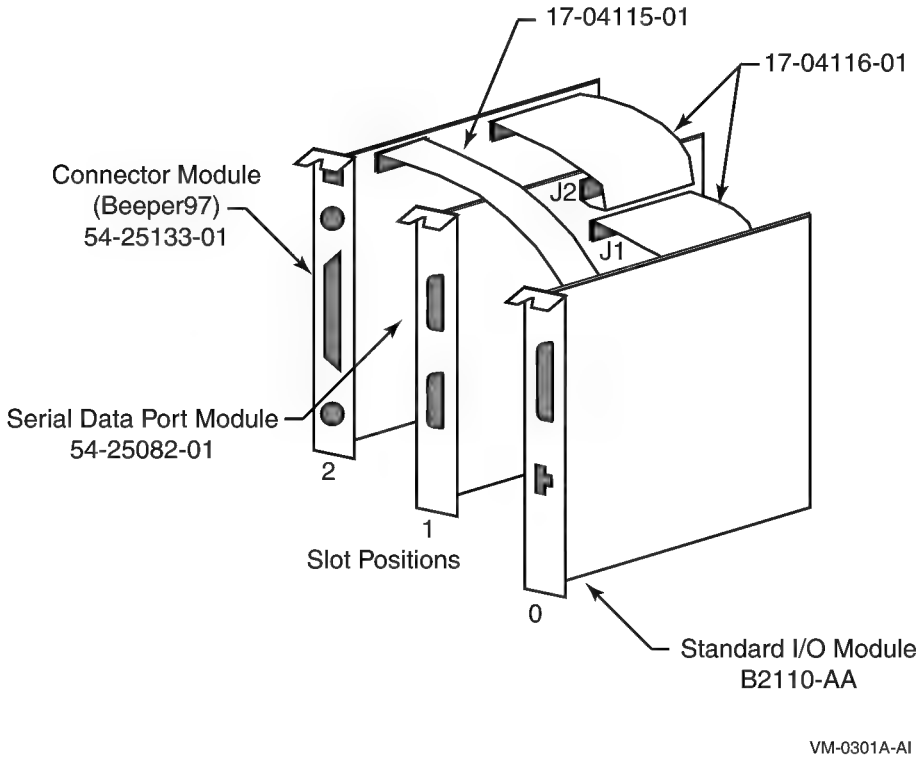
Insert Modules and Connect Ribbon Cables

NOTE When installing PCI modules, be sure the option bulkheads mate with the EMI gasket on the PCI card cage.

KFE72-DA modules must occupy slots 0, 1, and 2 of the DWLPB card cage.

To insert the modules in the PCI card cages and connect the appropriate ribbon cables, see Figure 5-1 and perform the following steps:

Figure 5-1 Attaching Ribbon Cables



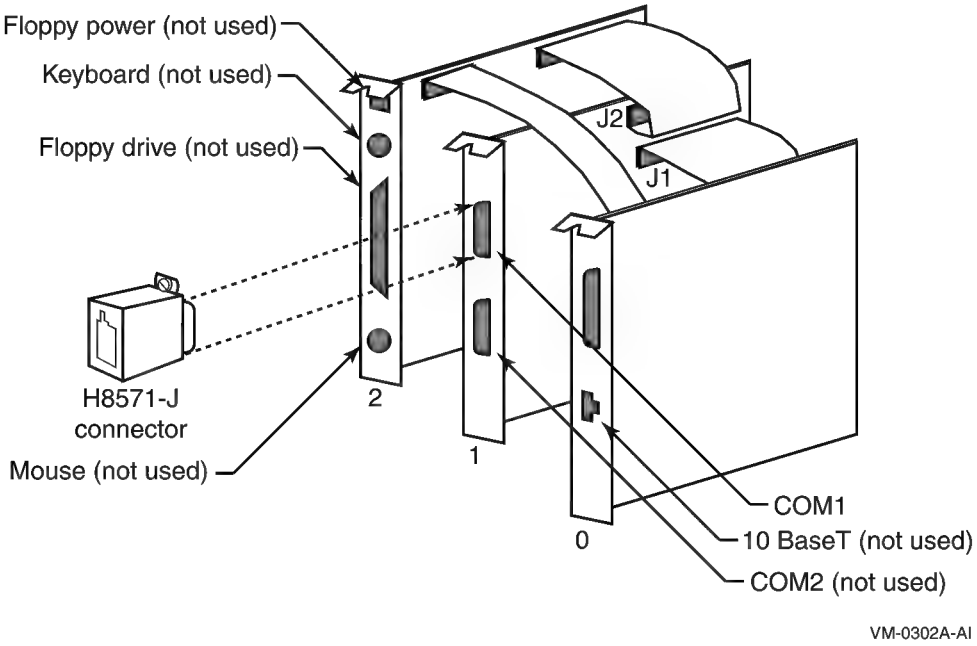
1. Insert the standard I/O module (B2110-AA) in slot 0. Secure the module to the card cage with a screw.
2. Attach the 60-pin ribbon cables (17-04116-01) on the serial port module (54-25082-01) at connectors J1 and J2.
3. Insert the serial port module (54-25082-01) in slot 1. Secure the module to the card cage with a screw.
4. Attach the 60-pin ribbon cable (17-04116-01) from the serial port module at connector J1 to the standard I/O module.
5. Insert the connector module in slot 2.
6. Attach the 34-pin ribbon cable (17-04115-01) between the standard I/O module (B2110-AA) in slot 0 and the connector module (54-25133-01) in slot 2.
7. Attach the 60-pin ribbon cable (17-04116-01) from the serial port module at connector J2 to the connector module.

Attaching the Connectors

To connect the console terminal and additional devices, see Figure 5-2 and connect the console serial line (H8571-J connector) to COM1.

Note that the pair of arrows between the numbers 1 and 2 on the serial port module is an industry standard symbol for a serial port and does not indicate port numbers.

Figure 5-2 Connectors



Slide Shelf Back Into System

To return the card cage, follow steps 2 through 9 in the procedure in Section 5.2.3 of the *KFE72 Installation Guide*.

Using a Terminal Server

You may want to bring your console lines together using a terminal server. For example, use a DECserver200 to allow reverse-LAT access to each console over the network. While this is not strictly required, it greatly simplifies OpenVMS Galaxy configuration management. See the appropriate product documentation for details about configuring a LAT Server or other terminal concentrator.

Installing EISA Devices

Plug-in EISA devices can only be configured in partition 0. After installing EISA devices, the console issues a message requesting that you run the EISA Configuration Utility (ECU).

Run the ECU as follows:

1. Shut down all OpenVMS Galaxy instances.
2. Be sure your floppy disk drive is properly connected to the primary partitions hardware. Typically the drive can be cabled into the Connector Module (Beeper part number 54-25133-01) in PCI slot 2.

3. Insert the diskette containing the ECU image.
4. Enter the following commands from the primary console:

```
P00>>> SET ARC_ENABLE ON
P00>>> INITIALIZE
P00>>> RUN ECU
```

5. Follow the procedures outlined by the ECU and exit when done.
6. Enter the following commands from the primary console:

```
P00>>> boot
        $ @SYS$SYSTEM:SHUTDOWN
        P00>>> SET ARC_ENABLE OFF
        P00>>> INITIALIZE
        P00>>> LPINIT
```

7. Reboot the OpenVMS Galaxy.

There are two versions of the ECU, one that runs on a graphics terminal and another that runs on character-cell terminals. Both versions are on the diskette, and the console determines which one to run. For OpenVMS Galaxy systems, the primary console is always a serial device with a character-cell terminal.

If the ECU is not run, OpenVMS displays the following message:

```
    %SYSTEM-I-NOCONFIGDATA, IRQ Configuration data for EISA
slot xxx was not found, please run the ECU and reboot.
```

If you ignore this message, the system boots, but the plug-in EISA devices are ignored.

Once you have configured and set up the OpenVMS Galaxy hardware as described in the previous sections, perform the following steps to install and boot OpenVMS Galaxy instances.

Step 3: Create a System Disk

Decide whether to use a system disk per instance or whether to use a cluster common disk.

A new SECURITY.EXE is required for all cluster members running a version prior to OpenVMS Version 7.1-2 that share the same VMS$OBJECTS.DAT file with Galaxy instances.

Step 4: Install OpenVMS Alpha

No special installation procedures are required to run OpenVMS Galaxy software. Galaxy functionality is included in the base operating system and can be enabled or disabled using the console command and system parameter values described later in this chapter.

For more information about installing the OpenVMS Alpha operating system, see the *HP OpenVMS Alpha Version 7.3-2 Upgrade and Installation Manual*.

OpenVMS Galaxy Licensing Information

For information on licensing, see the *OpenVMS License Management Utility Manual.*

Step 5: Upgrade the Firmware

Creating an OpenVMS Galaxy environment on an AlphaServer 8400 requires a firmware upgrade to each processor module. If you use these modules again in a non-Galaxy configuration, you need to reinstall the previous firmware. It is a good practice to have a current firmware CD on hand.

It saves some time if you install all processor modules you intend to use and update them at the same time. The AlphaServer 8400 requires that you use the same firmware on all processor boards. If you need to upgrade a board at a later time, you must:

1. Remove all the boards that are not at the same firmware revision level.
2. Update the older boards.
3. Reinstall the remaining boards.

To upgrade your firmware, the system must be powered on, running in non-Galaxy mode (that is, the LP_COUNT console environment variable—if you have established it—must be set to zero).

To set the console environment variable, enter the following commands:

```
P00>>> SET LP_COUNT 0
P00>>> INIT
```

To upgrade the firmware, use the standard console firmware update available from AlphaSystem Engineering. To download the current firmware version, check the Alpha Systems Firmware web site at the following location:

```
http://ftp.digital.com/pub/DEC/Alpha/firmware/
```

Step 6: Set the Environment Variables

When you have upgraded the firmware on all of your processor modules, you can create the Galaxy-specific environment variables as shown in the following example. This example assumes you are configuring a 2-instance, 8-CPU, 1-GB OpenVMS Galaxy computing environment.

```
P00>>> create -nv lp_count          2
P00>>> create -nv lp_cpu_mask0      1
P00>>> create -nv lp_cpu_mask1      fe
P00>>> create -nv lp_io_mask0       100
P00>>> create -nv lp_io_mask1       80
P00>>> create -nv lp_mem_size0      10000000
P00>>> create -nv lp_mem_size1      10000000
P00>>> create -nv lp_shared_mem_size  20000000
P00>>> init
```

After you create these variables, you can use console SET commands to manipulate them. These variables need only be created on processor 0.

The following descriptions give detailed information about each environment variable.

LP_COUNT *number*

If set to zero, the system boots a traditional SMP configuration only. The Galaxy console mode is OFF.

If set to a nonzero value, the Galaxy features are used, and the Galaxy variables are interpreted. The exact value of LP_COUNT represents the number of Galaxy partitions the console should expect. This number must be 0, 2, or 3.

Note that if you assign resources for three partitions and set this variable to two, the remaining resources are left unassigned. Unassigned CPUs are assigned to partition 0. You may also create the variables for the maximum number of partitions ahead of time and simply not assign resources to them (set them to nonzero values) until needed.

LP_CPU_MASK*n* *mark*

This bit mask determines which CPUs are to be initially assigned to the specified Galaxy partition number. The AlphaServer 8400 console chooses the first even-numbered CPU in a partition as its primary CPU, beginning with CPU 0 for the initial instance. Keep this in mind when assigning the resources. (In other words, do not assign only an odd-numbered CPU to a partition.)

LP_IO_MASK*n* *mask*

These variables assign I/O modules by slot number to each instance:

- 100 represents the I/O module in slot 8.
- 80 represents the I/O module in slot 7.
- 40 represents the I/O module in slot 6.

These are the only valid assignments for the AlphaServer 8400.

You can assign more than one I/O module to an instance using these masks, but each Galaxy instance requires at least one I/O module.

LP_MEM_SIZE*n* *size*

These variables allocate a specific amount of private memory for the specified instance. It is imperative that you create these variables using proper values for the amount of memory in your system, and the desired assignments for each instance. See Appendix B for common values.

See also the shared memory variable text that follows.

LP_SHARED_MEM_SIZE *size*

This variable allocates memory for use as shared memory. See Appendix B for common values.

NOTE Shared memory must be assigned in multiples of 8 MB and all values are expressed in hexadecimal bytes.

You can define only the amount of shared memory to use, and leave the other LP_MEM_SIZE variables undefined. This causes the console to allocate the shared memory from the high address space, and to split the remaining memory equally among the number of partitions specified by the LP_COUNT variable. If you also explicitly assign memory to a specific partition using a LP_MEM_SIZE variable, but you leave other partition memory assignments

undefined, the console again assigns the memory fragments for shared memory and any partitions with explicit assignments, and then splits and assigns the remaining memory to any remaining partitions not having explicit memory assignments.

BOOTDEF_DEV and BOOT_OSFLAGS *variables*

Before booting, set these variables on each of your Galaxy consoles to ensure that AUTOGEN reboots correctly after an initial installation and after a system failure or operator-requested reboot.

Galaxy Environment Variables Example

```
P00>>> SHOW LP*

lp_count 2
lp_shared_mem_size 20000000   (512 MB)
lp_mem_size0 10000000 (256 MB)
lp_mem_size1 10000000 (256 MB)
lp_cpu_mask0 1 (CPU 0)
lp_cpu_mask1 fe (CPUs 1-7)
lp_io_mask0 100 (I/O module in slot 8)
lp_io_mask1 80 (I/O module in slot 7)

P00>>
```

Step 7: Start the Secondary Console Devices

If the KFE72-DA was configured for Windows NT, it expects to find the video board and hangs if one is not present. This is a common occurrence when configuring an OpenVMS Galaxy. Use this console command to set the mode of operation as follows:

```
P00>>> SET CONSOLE SERIAL
```

When you enter this command to the primary console before initializing the secondary consoles, the setting is propagated to the secondary console hardware.

If you decide to use the Ethernet port, you may need to inform the console of which media type and connection you intend to use: AUI, UDP, or twisted pair. The console and operating system determine which to use, but you can assign a specific media type by entering the following commands:

```
P00>>> SHOW NETWORK

P00>>> SET EWA0_MODE TWISTED
```

The first command displays a list of available network devices. The second command establishes the default media type for the specified device (EWA0 in this example). This should be done for all Ethernet devices before initializing the secondary consoles.

Once you have set your console mode and network media types (if used), reinitialize the system to ensure that the current settings are saved. If you have already defined your Galaxy partitions, you can initialize now. If you have not defined your Galaxy partitions, defer initialization until later.

If you are ready to initialize the system, enter:

```
P00>>> INIT
```

You should see the primary console respond with its usual power-up self-test (POST) report. This could take up to 2 minutes. If you have properly defined the Galaxy partitions, only the I/O devices associated with the primary partition are visible.

To verify that partitioning has occurred, enter:

```
P00>>> SHOW DEVICE
```

or

```
P00>>> SHOW NETWORK
```

To initialize the secondary console, enter:

```
P00>>> LPINIT
```

The console displays the following:

```
Partition 0: Primary CPU = 0
Partition 1: Primary CPU = 2
Partition 0: Memory Base = 000000000   Size = 010000000
Partition 1: Memory Base = 010000000   Size = 010000000
Shared Memory Base = 020000000   Size = 010000000
LP Configuration Tree = 12c000
starting cpu 1 in Partition 1 at address 01000c001
starting cpu 2 in Partition 1 at address 01000c001
starting cpu 3 in Partition 1 at address 01000c001
starting cpu 4 in Partition 1 at address 01000c001
starting cpu 5 in Partition 1 at address 01000c001
starting cpu 6 in Partition 1 at address 01000c001
starting cpu 7 in Partition 1 at address 01000c001

P00>>>
```

This command must be entered from the primary Galaxy console. If the Galaxy partitions have been properly defined and hardware resources have been properly configured, you should see the primary console start the processors assigned to each secondary partition. Each of the secondary consoles should initialize within 2 minutes.

If one or more consoles fails to initialize, double-check your hardware installation, Galaxy partition definitions, and hardware assignments.

For more information about OpenVMS console restrictions and hints, see Chapter 12.

Step 8: Boot the OpenVMS Galaxy

When you have correctly installed the Galaxy firmware and configured the consoles, you can boot the initial Galaxy environment as follows:

For each Galaxy instance:

```
P00>>> B -FL 0,1 DKA100 // or whatever your boot device is.

SYSBOOT> SET GALAXY 1

SYSBOOT> CONTINUE
```

Congratulations! You have created an OpenVMS Galaxy.

6 Creating an OpenVMS Galaxy on an AlphaServer 8200 System

This chapter describes the process to create an OpenVMS Galaxy computing environment on an AlphaServer 8200. It focuses on procedures that differ from the AlphaServer 8400 procedures in Chapter 5.

Step 1: Choose a Configuration and Determine Hardware Requirements

Quick Summary of the Only Possible AlphaServer 8200 Galaxy Configuration

- 2 instances only
- 5 slots for:
  - — 2 processor modules (two CPUs each)
  - — 2 I/O modules
  - — 1 memory module

Step 2: Set Up Galaxy Hardware

When you have acquired the necessary hardware for your configuration, follow the procedures in Overview of KFE72-DA Console Subsystem Hardware through Using a Terminal Server in Chapter 5 and then in this section.

Installing EISA Devices

Plug-in EISA devices can only be configured in partition 0. After installing EISA devices, the console issues a message requesting that you run the EISA Configuration Utility (ECU).

Run the ECU as follows:

1. Shut down all OpenVMS Galaxy instances.
2. Be sure your floppy disk drive is properly connected to the primary partitions hardware. Typically the drive can be cabled into the connector module (Beeper part number 54-25133-01) in PCI slot 2.
3. Insert the diskette containing the ECU image.
4. Enter the following commands from the primary console:

```
P08>>> SET ARC_ENABLE ON
P08>>> INITIALIZE
P08>>> RUNECU
```

5. Follow the procedures outlined by the ECU and exit when done.
6. Enter the following commands from the primary console:

```
P08>>> boot
        $ @SYS$SYSTEM:SHUTDOWN
        P08>>> SET ARC_ENABLE OFF
P08>>> INITIALIZE
P08>>> LPINIT
```

7. Reboot the OpenVMS Galaxy.

There are two versions of the ECU, one that runs on a graphics terminal and another that runs on character-cell terminals. Both versions are on the diskette, and the console determines which one to run. For OpenVMS Galaxy systems, the primary console is always a serial device with a character-cell terminal.

If the ECU is not run, OpenVMS displays the following message:

```
    %SYSTEM-I-NOCONFIGDATA, IRQ Configuration data for EISA
slot xxx was not found, please run the ECU and reboot.
```

If you ignore this message, the system boots, but the plug-in EISA devices are ignored.

Once you have configured and set up the OpenVMS Galaxy hardware as described in the previous sections, perform the following steps to install and boot OpenVMS Galaxy instances.

Step 3: Create a System Disk

Decide whether to use a system disk per instance or whether to use a cluster common disk.

A new SECURITY.EXE is required for all cluster members running a version prior to OpenVMS Version 7.1-2 that share the same VMS$OBJECTS.DAT file with Galaxy instances.

Step 4: Install OpenVMS Alpha Version 7.3

No special installation procedures are required to run OpenVMS Galaxy software. Galaxy functionality is included in the base operating system and can be enabled or disabled using the console command and system parameter values described later in this chapter.

For more information about installing the OpenVMS Alpha operating system, see the *HP OpenVMS Alpha Version 7.3-2 Upgrade and Installation Manual*.

For information on OpenVMS Galaxy licensing, see the *OpenVMS License Management Utility Manual*.

Step 5: Upgrade the Firmware

Creating an OpenVMS Galaxy environment on an AlphaServer 8200 requires a firmware upgrade to each processor module. If you use these modules again in a non-Galaxy configuration, you need to reinstall the previous firmware. It is a good practice to have a current firmware CD on hand.

It saves some time if you install all processor modules you intend to use and update them at the same time. The AlphaServer 8200 requires that you use the same firmware on all processor boards. If you need to upgrade a board at a later time, you must:

1. Remove all the boards that are not at the same firmware revision level.
2. Update the older boards.
3. Reinstall the remaining boards.

To upgrade your firmware, the system must be powered on, running in non-Galaxy mode (that is, the LP_COUNT console environment variable—if you have established it—must be set to zero).

To set the console environment variable, enter the following commands:

```
P08>>> SET LP_COUNT 0
P08>>> INIT
```

To upgrade the firmware, use the standard console firmware update available from Alpha Systems Engineering.

Step 6: Set the Environment Variables

When you have upgraded the firmware on all of your processor modules, you can create the Galaxy-specific environment variables as shown in the following example. This example assumes you are configuring a 2-instance, 4-CPU, 1-GB OpenVMS Galaxy computing environment.

```
P08>>> create -nv lp_count          2
P08>>> create -nv lp_cpu_mask0      100
P08>>> create -nv lp_cpu_mask1      e00
P08>>> create -nv lp_io_mask0       100
P08>>> create -nv lp_io_mask1       80
P08>>> create -nv lp_mem_size0      10000000
P08>>> create -nv lp_mem_size1      10000000
P08>>> create -nv lp_shared_mem_size  20000000
P08>>> init
```

After you create these variables, you can use console SET commands to manipulate them. These variables need only be created on processor 0.

The following descriptions give detailed information about each environment variable.

LP_COUNT *numbr*

If set to zero, the system boots a traditional SMP configuration only. The Galaxy console mode is OFF.

If set to a nonzero value, the Galaxy features are used, and the Galaxy variables are interpreted. The exact value of LP_COUNT represents the number of Galaxy partitions the console should expect.

LP_CPU_MASK*n mask*

This bit mask determines which CPUs are to be initially assigned to the specified Galaxy partition number. The AlphaServer 8200 console chooses the first even-numbered CPU as its primary CPU, beginning with CPU 08 for the initial instance. Keep this in mind when assigning the resources. (In other words, do not assign only an odd-numbered CPU to a partition.)

LP_IO_MASK*n mask*

These variables assign IO processors by slot number to each instance:

- 100 represents the I/O module in slot 8.
- 80 represents the I/O module in slot 7.

These are the only valid assignments for the AlphaServer 8200.

LP_MEM_SIZE*n size*

These variables allocate a specific amount of private memory for the specified instance. It is imperative that you create these variables using proper values for the amount of memory in your system and the desired assignments for each instance. See Appendix B for the values commonly used.

See also the shared memory variable on the following line.

LP_SHARED_MEM_SIZE *size*

This variable allocates memory for use as shared memory. See Appendix B for the values commonly used.

NOTE Shared memory must be assigned in multiples of 8 MB and all values are expressed in hexadecimal bytes.

You can define only the amount of shared memory to use, and leave the other LP_MEM_SIZE variables undefined. This causes the console to allocate the shared memory from the high address space, and to split the remaining memory equally among the number of partitions specified by the LP_COUNT variable. If you also explicitly assign memory to a specific partition using a LP_MEM_SIZE variable, but leave the other partition memory assignments undefined, the console again assigns the memory fragments for shared memory and any partitions with explicit assignments, then splits and assigns the remaining memory to any remaining partitions not having explicit memory assignments.

BOOTDEF_DEV and BOOT_OSFLAGS *variables*

Before booting, set these variables on each of your Galaxy consoles to ensure that AUTOGEN reboots correctly when it needs to reboot the system after an initial installation and after a system crash or operator requested reboot.

Galaxy Environment Variables Example

```
P08>>> SHOW LP*

lp_count 2
lp_shared_mem_size 20000000   (512 MB)
lp_mem_size0 10000000 (256 MB)
lp_mem_size1 10000000 (256 MB)
lp_cpu_mask0 100 (CPU 0)
lp_cpu_mask1 e00 (CPUs 1-3)
lp_io_mask0 100 (I/O module in slot 8)
```

```
lp_io_mask1 80 (I/O module in slot 7)

P08>>>
```

Step 7: Start the Secondary Console Device

If the KFE72-DA was configured for Windows NT, it expects to find the video board and hangs if one is not present. This is a common occurrence when configuring an OpenVMS Galaxy. Use this console command to set the mode of operation as follows:

```
P08>>> SET CONSOLE SERIAL
```

When you enter this command to the primary console before initializing the secondary console, the setting is propagated to the secondary console hardware.

If you decide to use the Ethernet port, you may need to inform the console of which media type and connection you intend to use: AUI, UDP, or twisted-pair. The console and operating system determines which to use, but you can assign a specific media type by entering the following commands:

```
P08>>> SHOW NETWORK

P08>>> SET EWA0_MODE TWISTED
```

The first command displays a list of available network devices. The second command establishes the default media type for the specified device (EWA0 in this example). This should be done for all Ethernet devices before initializing the secondary console.

Once you have set your console mode and network media types (if used), reinitialize the system to ensure that the current settings are saved. If you have already defined your Galaxy partitions, you can initialize now. If you have not defined your Galaxy partitions, defer initialization until later.

If you are ready to initialize the system, enter:

```
P08>>> INIT
```

You should see the primary console respond with its usual power-up self-test (POST) report. This could take up to 2 minutes. If you have properly defined the Galaxy partitions, only the I/O devices associated with the primary partition are visible.

To verify that partitioning has occurred, enter:

```
P08>>> SHOW DEVICE
```

or

```
P08>>> SHOW NETWORK
```

To initialize the secondary console, enter:

```
P08>>> LPINIT
```

The console displays the following:

```
Partition 0: Primary CPU = 0
Partition 1: Primary CPU = 2
Partition 0: Memory Base = 000000000   Size = 010000000
Partition 1: Memory Base = 010000000   Size = 010000000
Shared Memory Base = 020000000   Size = 010000000
LP Configuration Tree = 12c000
```

```
starting cpu 1 in Partition 1 at address 01000c001
starting cpu 2 in Partition 1 at address 01000c001
starting cpu 3 in Partition 1 at address 01000c001

P08>>>
```

This command must be entered from the primary Galaxy console. If the Galaxy partitions have been properly defined and hardware resources have been properly configured, you should see the primary console start the processors assigned to the secondary partition. The secondary console should initialize within 2 minutes.

If one or more consoles fails to initialize, double-check your hardware installation, Galaxy partition definitions, and hardware assignments.

For more information about OpenVMS console restrictions and hints, see Chapter 12.

Step 8: Boot the OpenVMS Galaxy

When you have correctly installed the Galaxy firmware and configured the consoles, you can boot the initial Galaxy environment as follows:

For each Galaxy instance, enter the following commands:

```
P08>>> B -FL 0,1 DKA100 // or whatever your boot device is.

SYSBOOT> SET GALAXY 1

SYSBOOT> CONTINUE
```

Congratulations! You have created an OpenVMS Galaxy.

7 Creating an OpenVMS Galaxy on an AlphaServer 4100 System

This chapter describes the requirements and procedures to create an OpenVMS Galaxy computing environment on an AlphaServer 4100.

Before You Start

To create an OpenVMS Galaxy on an AlphaServer 4100, you must be familiar with the following configuration and hardware requirements:

Two-instance maximum

You can run a maximum of two instances of OpenVMS on an AlphaServer 4100.

Console firmware

You must have AlphaServer 4100 console firmware that is available on the OpenVMS Version 7.3 CD-ROM.

Console commands

In addition to the console hints in Chapter 5, note the following:

- Enter console commands on one instance at a time.
- Do not enter console commands at another console until the command entered at the first console has completed.

AlphaServer 4100 clock

An AlphaServer 4100 has one clock. For an OpenVMS Galaxy, this means that you cannot run the two instances at different times. Also, the SET TIME command affects both instances. Note that this may not become evident until a number of hours have passed.

Console ports

COM1 (upper) is the console port for instance 0. COM2 (lower) is the console port for instance 1.

Unlike creating an OpenVMS Galaxy on an AlphaServer 8400, you do not need additional hardware for the second console. COM2 is used for this purpose.

CPUs

CPU0 must be the primary for instance 0. CPU1 must be the primary for instance 1. CPUs 2 and 3 are optional secondary CPUs that can be migrated.

I/O adapters

The four lower PCI slots belong to IOD0, which is the I/O adapter for instance 0. The four upper PCI slots belong to IOD1, which is the I/O adapter for instance 1.

Storage controllers

You need two storage controllers, such as KZPSAs. These can go to separate StorageWorks boxes or to the same box for running as a SCSI cluster. One controller each goes in IOD0 and IOD1.

Network cards

If each instance needs network access, a network card (such as a DE500) is required for each instance.

One card each goes in IOD0 and IOD1.

Physical memory

Because OpenVMS Galaxy on an AlphaServer 4100 does not support memory holes, physical memory for an OpenVMS Galaxy environment must be contiguous. To achieve this on an AlphaServer 4100, one of the following must be true:

- All memory modules must be the same size (for example, 1 GB).
- If two sizes are present, only one module can be a smaller size. You must put the larger modules into the lower numbered slots.

To create an OpenVMS Galaxy on an AlphaServer 4100 system, perform the steps in the following sections.

Step 1: Confirm the AlphaServer 4100 Configuration

Use the SHOW CONFIG command to make sure that the AlphaServer 4100 you are using to create an OpenVMS Galaxy environment meets the requirements described in Before You Start.

At the console prompt, enter the following command:

```
P00>>>show config
```

The console displays the following information:

```
Console G53_75  OpenVMS PALcode V1.19-16, UNIX PALcode V1.21-24

Module                          Type     Rev    Name
System Motherboard              0        0000   mthrbrd0
Memory  512 MB EDO              0        0000   mem0
Memory  256 MB EDO              0        0000   mem1
CPU (Uncached)                  0        0000   cpu0
CPU (Uncached)                  0        0000   cpu1
Bridge (IOD0/IOD1)              600      0021   iod0/iod1
PCI Motherboard                 8        0000   saddle0
CPU (Uncached)                  0        0000   cpu2
CPU (Uncached)                  0        0001   cpu3

Bus 0  iod0 (PCI0)
Slot   Option Name              Type     Rev    Name
1      PCEB                     4828086  0005   pceb0
4      DEC KZPSA                81011    0000   pks1
5      DECchip 21040-AA         21011    0023   tulip1

Bus 1  pceb0 (EISA Bridge connected to iod0, slot 1)
Slot   Option Name              Type     Rev    Name

Bus 0  iod1 (PCI1)
Slot   Option Name              Type     Rev    Name
```

```
1       NCR 53C810              11000    0002   ncr0
2       DECchip 21040-AA        21011    0024   tulip0
3       DEC KZPSA               81011    0000   pks0
```

Step 2: Install OpenVMS Alpha Version 7.3-2

No special installation procedures are required to run OpenVMS Galaxy software. Galaxy functionality is included in the base operating system and can be enabled or disabled using the console command and system parameter values described later in this chapter.

If your AlphaServer 4100 is not part of a SCSI cluster, you must install OpenVMS Version 7.3 on two system disks—one disk for each instance.

If your AlphaServer 4100 is part of a SCSI cluster with a cluster-common system disk, install OpenVMS Version 7.3 on one system disk.

For more information about installing the OpenVMS Alpha operating system, see the *HP OpenVMS Alpha Version 7.3-2 Upgrade and Installation Manual*.

Step 3: Upgrade the Firmware

To upgrade the firmware, use the Alpha Systems Firmware Update Version 5.4 CD–ROM that is included in the OpenVMS Version 7.3 CD–ROM package. Be sure to read the release notes that are included in the package before installing the firmware.

Step 4: Set the Environment Variables

Configure the primary console for instance 0.

CPU0 is the primary for instance 0.

Create the Galaxy environment variables. For descriptions of the Galaxy environment variables and common values for them, see Chapter 5.

The following example is for an AlphaServer 4100 with three CPUs and 512 MB of memory divided into 256 MB + 192 MB + 64 MB:

```
P00>>> create -nv lp_count            2
P00>>> create -nv lp_cpu_mask0        1
P00>>> create -nv lp_cpu_mask1        6
P00>>> create -nv lp_io_mask0         10
P00>>> create -nv lp_io_mask1         20
P00>>> create -nv lp_mem_size0        10000000
P00>>> create -nv lp_mem_size1        c000000
P00>>> create -nv lp_shared_mem_size  4000000
P00>>> set auto_action halt
```

If you have four CPUs and you want to assign all secondary CPUs to instance 1, the LP_CPU_MASK1 variable will be E. If you split the CPUs between both instances, CPU 0 must be the primary for instance 0, and CPU 1 must be the primary CPU for instance 1.

The MEM_SIZE variables depend on your configuration and how you want to split it up.

- lp_io_mask0 must be set to 10.
- lp_io_mask1 must be set to 20.

You must set the console environment variable AUTO_ACTION to HALT. This ensures that the system does not boot and that you are able to enter the Galaxy command.

Step 5: Initialize the System and Start the Console Devices

1. Initialize the system and start the Galaxy firmware by entering the following commands:

   ```
   P00>>> init
   P00>>> galaxy
   ```

   After the self-test completes, the Galaxy command starts the console on instance 1.

   The first time that the Galaxy starts, it might display several messages like the following:

   ```
   CPU0 would not join

   IOD0 and IOD1 did not pass the power-up self-test
   ```

   This happens because there are two sets of environment variables, and the Galaxy variables are not present initially on instance 1.

   Note that when the I/O bus is divided between the two Galaxy partitions, the port letter of a device might change. For example, a disk designated as DKC300 when the AlphaServer 4100 is a single system could become DKA300 when it is configured as partition 0 of the OpenVMS Galaxy.

2. Configure the console for instance 1:

   ```
   P01>>> create -nv lp_cpu_mask0        1
   P01>>> create -nv lp_cpu_mask1        6
   P01>>> create -nv lp_io_mask0         10
   P01>>> create -nv lp_io_mask1         20
   P01>>> create -nv lp_mem_size0        10000000
   P01>>> create -nv lp_mem_size1        c000000
   P01>>> create -nv lp_count       2
   P01>>> create -nv lp_shared_mem_size  4000000
   P01>>> set auto_action halt
   ```

3. Initialize the system and restart the Galaxy firmware by entering the following command:

   ```
   P00>>> init
   ```

   When the console displays the following confirmation prompt, type Y:

   ```
   Do you REALLY want to reset the Galaxy (Y/N)
   ```

4. Configure the system root, boot device, and other related variables.

   The following example settings are from an OpenVMS Engineering system. Change these variables to meet the needs of your own environment.

```
P00>>> set boot_osflags12,0
P00>>> set bootdef_devdka0
P00>>> set boot_resetoff            !!! must be OFF !!!
P00>>> set ewa0_modetwisted

P01>>> set boot_osflags11,0
P01>>> set bootdef_devdkb200
P01>>> set boot_resetoff            !!! must be OFF !!!
P01>>> set ewa0_modetwisted
```

5. Boot instance 1 as follows:

   ```
   P01>>> boot
   ```

   Once instance 1 is booted, log in to the system account and edit the SYS$SYSTEM:MODPARAMS.DAT file to include the following line:

   ```
   GALAXY=1
   ```

   Confirm that the lines for the SCS node and SCS system ID are correct. Run AUTOGEN as follows to configure instance 1 as a Galaxy member, and leave the system halted:

   ```
   $ @SYS$UPDATE:AUTOGEN GETDATA SHUTDOWN INITIAL
   ```

6. Boot instance 0 as follows:

   ```
   P00>>> boot
   ```

   Once instance 0 is booted, log in to the system account and edit the SYS$SYSTEM:MODPARAMS.DAT file to include the following line:

   ```
   Add the line GALAXY=1
   ```

   Confirm that the lines for the SCS node and SCS system ID are correct. Run AUTOGEN as follows to configure instance 0 as a Galaxy member, and leave the system halted:

   ```
   $ @SYS$UPDATE:AUTOGEN GETDATA SHUTDOWN INITIAL
   ```

7. Prepare the Galaxy to come up automatically upon initialization or power cycle of the system. Set the AUTO_ACTION environment variable on both instances to RESTART:

   ```
   P00>>> set auto_action restart

   P01>>> set auto_action restart
   ```

8. Initialize the Galaxy again by entering the following command at the primary console:

   ```
   P00>>> init
   ```

   When the console displays the following confirmation prompt, type Y:

   ```
   Do you REALLY want to reset the Galaxy (Y/N)
   ```

   Alternatively, you could power-cycle your system, and the Galaxy with both instances should bootstrap automatically.

Congratulations! You have created an OpenVMS Galaxy.

8 Creating an OpenVMS Galaxy on an AlphaServer ES40 System

This chapter describes the requirements and procedures to create an OpenVMS Galaxy computing environment on an AlphaServer ES40 system.

This chapter contains revised procedures that were originally published in the OpenVMS Alpha VMS721_DS20E_ES40 remedial kit.

To create an OpenVMS Galaxy on an AlphaServer ES40 system:

1. Read the configuration and hardware requirements in Before You Start.
2. Perform steps 1 through 5.

Before You Start

You must be familiar with the following AlphaServer ES40 configuration and hardware requirements:

Two-instance maximum

You can run a maximum of two instances of OpenVMS on an AlphaServer ES40.

Console firmware

To create an OpenVMS Galaxy environment on AlphaServer ES40 systems, you must download the latest version of the V6.2 console firmware from the following location:

```
http://ftp.digital.com/pub/DEC/Alpha/firmware/
```

AlphaServer ES40 clock

An AlphaServer ES40 has one clock. For an OpenVMS Galaxy, this means that you cannot run the two instances at different times. Also, the SET TIME command affects both instances. This may not become evident until a number of hours have passed.

Console ports

On a rack-mounted system: COM1 (lower) is the console port for instance 0. COM2 (upper) is the console port for instance 1.

On a pedestal system: COM1 (left) is the console port for instance 0. COM2 (right) is the console port for instance 1.

Unlike creating an OpenVMS Galaxy on an AlphaServer 8400, you do not need additional hardware for the second console. COM2 is used for this purpose.

CPUs

CPU0 must be the primary for instance 0. CPU1 must be the primary for instance 1. CPUs 2 and 3 are optional secondary CPUs that can be migrated.

For an example of the CPU environment variable settings on an AlphaServer ES40, see Step 4: Set the Environment Variables.

I/O adapters

On a rack-mounted system: PCI hose 0 (PCI0) belongs to instance 0 (upper 4 PCI slots) PCI hose 1 (PCI1) belongs to instance 1 (lower 6 PCI slots)

On a pedestal system: PCI hose 0 (PCI0) belongs to instance 0 (right-hand slots) PCI hose 1 (PCI1) belongs to instance 1 (left-hand slots)

Note that PCI0 contains an embedded ISA controller.

To see an I/O adapter configuration example, see Step 1: Confirm the AlphaServer ES40 Configuration.

Storage controllers

You need one storage controller (such as a KZPSA) per instance. For each instance, this can go to a separate StorageWorks box or to the same box for running as a SCSI cluster.

Network cards

If each instance needs network access, a network card (such as a DE600) is required for each instance.

One card each goes in PCI0 and PCI1.

Memory Granularity Restrictions

Private memory must start on a 64-MB boundary.

Shared memory must start on an 8-MB boundary.

Instance 0 must have a multiple of 64 MB.

Step 1: Confirm the AlphaServer ES40 Configuration

Use the SHOW CONFIG command to make sure that the AlphaServer ES40 you are using to create an OpenVMS Galaxy environment meets the requirements described in Before You Start.

At the console prompt, enter the following command:

```
P00>>>show config
```

The console displays information similar to the following example:

```
Firmware
SRM Console:    X5.6-2323
ARC Console:    v5.70
PALcode:        OpenVMS PALcode V1.61-2, Tru64 UNIX PALcode V1.54-2
Serial Rom:     V2.2-F
RMC Rom:        V1.0
RMC Flash Rom:  T2.0

Processors
CPU 0           Alpha 21264-4 500 MHz  4MB Bcache
CPU 1           Alpha 21264-4 500 MHz  4MB Bcache
CPU 2           Alpha 21264-4 500 MHz  4MB Bcache
CPU 3           Alpha 21264-4 500 MHz  4MB Bcache

Core Logic
Cchip           DECchip 21272-CA Rev 9(C4)
Dchip           DECchip 21272-DA Rev 2
Pchip 0         DECchip 21272-EA Rev 2
Pchip 1         DECchip 21272-EA Rev 2
```

```
TIG             Rev 10

Memory
  Array       Size       Base Address    Intlv Mode
---------  ----------  ----------------  ----------
    0       4096Mb     0000000000000000    2-Way
    1       4096Mb     0000000100000000    2-Way
    2       1024Mb     0000000200000000    2-Way
    3       1024Mb     0000000240000000    2-Way

     10240 MB of System Memory

 Slot   Option                  Hose 0, Bus 0, PCI
   1    DAPCA-FA ATM622 MMF
   2    DECchip 21152-AA                            Bridge to Bus 2, PCI
   3    DEC PCI FDDI            fwb0.0.0.3.0        00-00-F8-BD-C6-5C
   4    DEC PowerStorm
   7    Acer Labs M1543C                            Bridge to Bus 1, ISA
  15    Acer Labs M1543C IDE    dqa.0.0.15.0
                                dqb.0.1.15.0
                                dqa0.0.0.15.0       TOSHIBA CD-ROM XM-6302B
  19    Acer Labs M1543C USB

        Option                  Hose 0, Bus 1, ISA
        Floppy                  dva0.0.0.1000.0

 Slot   Option                  Hose 0, Bus 2, PCI
   0    NCR 53C875              pkd0.7.0.2000.0     SCSI Bus ID 7
   1    NCR 53C875              pke0.7.0.2001.0     SCSI Bus ID 7
                                dke100.1.0.2001.0   RZ1BB-CS
                                dke200.2.0.2001.0   RZ1BB-CS
                                dke300.3.0.2001.0   RZ1CB-CS
                                dke400.4.0.2001.0   RZ1CB-CS
   2    DE500-AA Network Con    ewa0.0.0.2002.0     00-06-2B-00-0A-58

 Slot   Option                  Hose 1, Bus 0, PCI
   1    NCR 53C895              pka0.7.0.1.1        SCSI Bus ID 7
                                dka100.1.0.1.1      RZ2CA-LA
                                dka300.3.0.1.1      RZ2CA-LA
   2    Fore ATM 155/622 Ada
   3    DEC PCI FDDI            fwa0.0.0.3.1        00-00-F8-45-B2-CE
   4    QLogic ISP10x0          pkb0.7.0.4.1        SCSI Bus ID 7
                                dkb100.1.0.4.1      HSZ50-AX
                                dkb101.1.0.4.1      HSZ50-AX
                                dkb200.2.0.4.1      HSZ50-AX
                                dkb201.2.0.4.1      HSZ50-AX
                                dkb202.2.0.4.1      HSZ50-AX
   5    QLogic ISP10x0          pkc0.7.0.5.1        SCSI Bus ID 7
                                dkc100.1.0.5.1      RZ1CB-CS
                                dkc200.2.0.5.1      RZ1CB-CS
                                dkc300.3.0.5.1      RZ1CB-CS
                                dkc400.4.0.5.1      RZ1CB-CS
   6    DECchip 21154-AA                            Bridge to Bus 2, PCI

 Slot   Option                  Hose 1, Bus 2, PCI
   4    DE602-AA                eia0.0.0.2004.1     00-08-C7-91-0A-AA
   5    DE602-AA                eib0.0.0.2005.1     00-08-C7-91-0A-AB
   6    DE602-TA                eic0.0.0.2006.1     00-08-C7-66-80-9E
   7    DE602-TA                eid0.0.0.2007.1     00-08-C7-66-80-5E
```

Step 2: Install OpenVMS Alpha Version 7.3–2

No special installation procedures are required to run OpenVMS Galaxy software. Galaxy functionality is included in the base operating system and can be enabled or disabled using the console command and system parameter values described later in this chapter.

If your AlphaServer ES40 is not part of a SCSI cluster, you must install OpenVMS Version 7.3–2 on two system disks—one disk for each instance.

If your AlphaServer ES40 is part of a SCSI cluster with a cluster-common system disk, install OpenVMS Version 7.3–2 on one system disk.

For more information about installing the OpenVMS Alpha operating system, see the *HP OpenVMS Alpha Version 7.3-2 Upgrade and Installation Manual*.

Step 3: Upgrade the Firmware

To upgrade the firmware, use one of the following procedures:

Copy the firmware file to MOM$SYSTEM on a MOP-enabled server that is accessible to the AlphaServer ES40. Enter the following commands on the console:

```
P00>>> boot -fl 0,0 ewa0 -fi {firmware filename}
UPD> update srm*
power-cycle system
```

Or, use the following commands:

```
P00>>> BOOT -FLAGS 0,A0 cd_device_name
.
.
.
Bootfile: {firmware filename}
.
.
.
```

Step 4: Set the Environment Variables

Configure the primary console for instance 0.

CPU0 is the primary for instance 0. CPU1 is the primary for instance 1.

The following example is for an AlphaServer ES40 with three CPUs and 512 MB of memory divided into 256 MB + 192 MB + 64 MB:

```
P00>>> set  lp_count            2
P00>>> set  lp_cpu_mask0        1
P00>>> set  lp_cpu_mask1        6
P00>>> set  lp_io_mask0         1
```

```
P00>>> set  lp_io_mask1          2
P00>>> set  lp_mem_size0         10000000
P00>>> set  lp_mem_size1         c000000
P00>>> set  lp_shared_mem_size   4000000
P00>>> set  console_memory_allocation new
P00>>> set auto_action halt
```

If you have four CPUs and you want to assign all secondary CPUs to instance 1, the LP_CPU_MASK1 variable will be E. If you split the CPUs between both instances, CPU 0 must be the primary for instance 0, and CPU 1 must be the primary CPU for instance 1.

The following example shows LP_CPU_MASK values for secondary CPU assignments with primary CPUs:

```
Assign secondary CPU 2 with primary CPU 0 and secondary CPU
3 with primary CPU 1.

>>>set lp_cpu_mask0 5
>>>set lp_cpu_mask1 A


CPU Selection                          LP_CPU_MASK

0(primary partition 0)                 2^0 =   1
1(primary partition 1)                 2^1 =   2
2(secondary)                           2^2 =   4
3(secondary)                           2^3 =   8
```

The MEM_SIZE variables depend on your configuration and how you want to split it up.

- lp_io_mask0 must be set to 1.
- lp_io_mask1 must be set to 2.

You must set the console environment variable AUTO_ACTION to HALT. This ensures that the system does not boot and that you are able to enter the LPINIT command.

Step 5: Initialize the System and Start the Console Devices

1. Initialize the system and start the Galaxy firmware by entering the following commands:

   ```
   P00>>> init      ! initialize the system
   P00>>> lpinit    ! start firmware
   ```

   After the self-test completes, the Galaxy command starts the console on instance 1.

   Note that when the I/O bus is divided between the two Galaxy partitions, the port letter of a device might change. For example, a disk designated as DKC300 when the AlphaServer ES40 is a single system could become DKA300 when it is configured as partition 0 of the OpenVMS Galaxy.

2. Configure the console for instance 1.
3. Configure the system root, boot device, and other related variables.

   The following example settings are from an OpenVMS Engineering system. Change these variables to meet the needs of your own environment.

```
      Instance 0
P00>>> set boot_osflags12,0
P00>>> set bootdef_devdka0
P00>>> set boot_resetoff            !!! must be OFF !!!
P00>>> set ewa0_modetwisted


      Instance 1
P01>>> set boot_osflags11,0
P01>>> set bootdef_devdkb200
P01>>> set boot_resetoff            !!! must be OFF !!!
P01>>> set ewa0_modetwisted
```

4. Boot instance 1 as follows:

   ```
   P01>>> boot
   ```

   Once instance 1 is booted, log in to the system account and edit the SYS$SYSTEM:MODPARAMS.DAT file to include the following line:

   ```
   GALAXY=1
   ```

   Confirm that the SCSNODE and SCSSYSTEMID SYSGEN parameters are correct. Run AUTOGEN as follows to configure instance 1 as a Galaxy member, and leave the system halted:

   ```
   $ @SYS$UPDATE:AUTOGEN GETDATA SHUTDOWN INITIAL
   ```

5. Boot instance 0 as follows:

   ```
   P00>>> boot
   ```

   Once instance 0 is booted, log in to the system account and edit the SYS$SYSTEM:MODPARAMS.DAT file to include the following line:

   ```
   GALAXY=1
   ```

   Confirm that the SCSNODE and SCSSYSTEMID SYSGEN parameters are correct. Run AUTOGEN as follows to configure instance 0 as a Galaxy member, and leave the system halted:

   ```
   $ @SYS$UPDATE:AUTOGEN GETDATA SHUTDOWN INITIAL
   ```

6. Prepare the Galaxy to come up automatically upon initialization or power cycle of the system. Set the AUTO_ACTION environment variable on both instances to RESTART:

   ```
   P00>>> set auto_action restart

   P01>>> set auto_action restart
   ```

7. Initialize the Galaxy again by entering the following command at the primary console:

   ```
   P00>>> init
   ```

   When the console displays the following confirmation prompt, type Y:

   ```
   Do you REALLY want to reset all partitions? (Y/N)
   ```

   Alternatively, you could power-cycle your system, and the Galaxy with both instances should bootstrap automatically.

Congratulations! You have created an OpenVMS Galaxy on an AlphaServer ES40 system.

9 Creating an OpenVMS Galaxy on AlphaServer GS80/160/320 Systems

This chapter describes the process to create an OpenVMS Galaxy computing environment on AlphaServer GS80/160/320 systems.

Step 1: Choose a Configuration and Determine Hardware Requirements

OpenVMS Alpha Version 7.3 supports the following maximum configuration on AlphaServer GS160 systems:

- 4 instances
- 4 QBBs
- 16 CPUs
- 128 GB memory

Rules:

- Must have standard COM1 UART console line for each partition
- Must have PCI drawer for each partition
- Must have an I/O module per partition
- Must have at least one CPU module per partition
- Must have at least one memory module per partition

Step 2: Set Up the Hardware

When you have acquired the necessary hardware for your configuration, follow the procedures in the appropriate hardware manuals to assemble it.

Step 3: Create a System Disk

Decide whether to use a system disk per instance or whether to use a cluster common-disk.

A new SECURITY.EXE file is required for all cluster members running a version prior to OpenVMS Version 7.1-2 that share the same VMS$OBJECTS.DAT file with Galaxy instances.

Step 4: Install OpenVMS Alpha Version 7.3-2

No special installation procedures are required to run OpenVMS Galaxy software. Galaxy functionality is included in the base operating system and can be enabled or disabled using the console command and system parameter values described later in this chapter.

For more information about installing the OpenVMS Alpha operating system, see the *HP OpenVMS Alpha Version 7.3-2 Upgrade and Installation Manual*.

OpenVMS Galaxy Licensing Information

In a Galaxy environment, the OPENVMS-GALAXY license units are checked during system startup and whenever a CPU reassignment between instances occurs.

If you attempt to start a CPU and there are insufficient OPENVMS-GALAXY license units to support it, the CPU remains in the instance's configured set but it is stopped. You can subsequently load the appropriate license units and start the stopped CPU while the system is running. This is true of one or more CPUs.

Step 5: Set the Environment Variables

When you have installed the operating system, you can set the Galaxy-specific environment variables as shown in the examples in this section.

AlphaServer GS160 Example

This example for an AlphaServer GS160 assumes you are configuring an OpenVMS Galaxy computing environment with:

- 4 instances
- 4 QBBs
- 16 CPUs
- 32 GB of memory

```
P00>>>show lp*

lp_count            4
lp_cpu_mask0        000F
lp_cpu_mask1        00F0
lp_cpu_mask2        0F00
lp_cpu_mask3        F000
lp_cpu_mask4        0
lp_cpu_mask5        0
lp_cpu_mask6        0
lp_cpu_mask7        0
lp_error_target     0
lp_io_mask0         1
lp_io_mask1         2
lp_io_mask2         4
lp_io_mask3         8
```

```
lp_io_mask4          0
lp_io_mask5          0
lp_io_mask6          0
lp_io_mask7          0
lp_mem_size0         0=4gb
lp_mem_size1         1=4gb
lp_mem_size2         2=4gb
lp_mem_size3         3=4gb
lp_mem_size4         0
lp_mem_size5         0
lp_mem_size6         0
lp_mem_size7         0
lp_shared_mem_size   16gb

P00>>>lpinit
```

AlphaServer GS320 Example

This example for an AlphaServer GS320 system assumes you are configuring an OpenVMS Galaxy computing environment with:

- 4 instances
- 8 QBBs
- 32 CPUs
- 32 GB memory

```
P00>>>show lp*

lp_count             4
lp_cpu_mask0         000F000F
lp_cpu_mask1         00F000F0
lp_cpu_mask2         0F000F00
lp_cpu_mask3         F000F000
lp_cpu_mask4         0
lp_cpu_mask5         0
lp_cpu_mask6         0
lp_cpu_mask7         0
lp_error_target      0
lp_io_mask0          11
lp_io_mask1          22
lp_io_mask2          44
lp_io_mask3          88
lp_io_mask4          0
lp_io_mask5          0
lp_io_mask6          0
lp_io_mask7          0
lp_mem_size0         0=2gb, 4=2gb
lp_mem_size1         1=2gb, 5=2gb
lp_mem_size2         2=2gb, 6=2gb
lp_mem_size3         3=2gb, 7=2gb
lp_mem_size4         0
lp_mem_size5         0
lp_mem_size6         0
lp_mem_size7         0
```

```
lp_shared_mem_size  16gb

P00>>>lpinit
```

Environment Variable Descriptions

This section describes each environment variable. For more details about using these variables, see the *AlphaServer GS80/160/320 Firmware Reference Manual.*

LP_COUNT *number*

If set to zero, the system boots a traditional SMP configuration only. The Galaxy console mode is OFF.

If set to a nonzero value, the Galaxy features are used, and the Galaxy variables are interpreted. The exact value of LP_COUNT represents the number of Galaxy partitions the console creates.

Note that if you assign resources for three partitions and set LP_COUNT to two, the remaining resources are left unassigned.

LP_CPU_MASK*n mask*

This bit mask determines which CPUs are to be initially assigned to the specified Galaxy partition number. The AlphaServer GS160 console chooses the first CPU that passes the self test in a partition as its primary CPU.

LP_ERROR_TARGET

The new Alphaserver GS series introduces a new Galaxy environment variable called LP_ERROR_TARGET. The value of the variable is the number of the Galaxy instance that system errors are initially reported to. Unlike other Galaxy platforms, all system correctable, uncorrectable, and system event errors go to a single instance. It is possible for the operating system to change this target, so the value of the variable represents the target when the system is first partitioned.

Every effort is made to isolate system errors to a single instance so that the error does not bring down the entire Galaxy. The error target instance determines, on receipt of an error, if it is safe to remotely crash the single instance that incurred the error. A bugcheck code of GLXRMTMCHK is used in this case. Note that error log information pertaining to the error is on the error target instance, not necessarily on the instance that incurred the error.

While every effort is made to keep the error target instance identical to the one the user designated with the environment variable, the software monitors the instances and changes the error target if necessary.

LP_IO_MASK*n mask*

These variables assign the I/O modules by QBB number to each instance:

Mask Value	QBB Number
1	QBB 0
2	QBB 1
4	QBB 2
8	QBB 3

For the *n*, supply the partition number (0 - 7). The value *mask* gives a binary mask indicating which QBB's (containing I/O risers) are included in the partition.

LP_MEM_SIZE*n size*

These variables allocate a specific amount of private memory for the specified instance. It is imperative that you create these variables using proper values for the amount of memory in your system and the desired assignments for each instance.

You can define only the amount of shared memory to use, and leave the other LP_MEM_SIZE variables undefined. This causes the console to allocate the shared memory from the high address space, and split the remaining memory equally among the number of partitions specified by the LP_COUNT variable. If you also explicitly assign memory to a specific partition using a LP_MEM_SIZE variable, but leave other partition memory assignments undefined, the console again assigns the memory fragments for shared memory and any partitions with explicit assignments, then splits and assigns the remaining memory to any remaining partitions not having explicit memory assignments.

For example:

```
lp_mem_size0  0=2gb, 1=2gb
```

NOTE Do not assign private memory to an instance from a QBB that has no CPUs in the instance.

For example, if LP_CPU_MASK0 is FF, then you should only assign private memory for instance 0 from QBBs 0 and 1.

See the *AlphaServer GS80/160/320 Firmware Reference Manual* for more details about using this variable.

LP_SHARED_MEM_SIZE *size*

This variable allocates memory for use as shared memory. For example:

```
lp_shared_mem_size      16gb
```

Shared memory must be assigned in multiples of 8 MB.

See the *AlphaServer GS80/160/320 Firmware Reference Manual* for more details about using this variable.

BOOTDEF_DEV and BOOT_OSFLAGS *variables*

Before booting, set these variables on each of your Galaxy consoles to ensure that AUTOGEN reboots correctly after an initial installation and after a system failure or operator-requested reboot.

Step 6: Start the Secondary Console Devices

If you decide to use the Ethernet port, you may need to inform the console which media type and connection you intend to use: AUI, UDP, or twisted pair. The console and operating system determine which to use, but you can assign a specific media type by entering the following commands:

```
P00>>> SHOW NETWORK

P00>>> SET EWA0_MODE TWISTED
```

The first command displays a list of available network devices. The second command establishes the default media type for the specified device (EWA0 in this example). This should be done for all Ethernet devices before initializing the secondary consoles.

Step 7: Initialize the Secondary Consoles

Once you have established the Galaxy variables, to initialize the secondary consoles, enter:

```
P00>>> LPINIT
```

The console displays the following:

```
P00>>>lpinit
lp_count = 2
lp_mem_size0 = 1800 (6 GB)
CPU 0 chosen as primary CPU for partition 0
lp_mem_size1 = 1800 (6 GB)
CPU 4 chosen as primary CPU for partition 1
lp_shared_mem_size = 1000 (4 GB)
initializing shared memory
partitioning system
QBB 0 PCA 0 Target 0 Interrupt Count = 2
QBB 0 PCA 0 Target 0 Interrupt CPU = 0
Interrupt Enable = 000011110000d05a
Sent Interrupts = 0000100000000010
Enabled Sent Interrupts = 0000100000000010
Acknowledging Sent Interrupt 0000000000000010 for CPU 0
QBB 0 PCA 0 Target 0 Interrupt Count = 1
QBB 0 PCA 0 Target 0 Interrupt CPU = 0
Interrupt Enable = 000011110000d05a
Sent Interrupts = 0000100000000000 Enabled Sent Interrupts = 0000100000000000
Acknowledging Sent Interrupt 0000100000000000 for CPU 0


OpenVMS PALcode V1.80-1, Tru64 UNIX PALcode V1.74-1

system = QBB 0 1 2 3         + HS                              (Hard Partition 0)
 QBB 0 = CPU 0 1 2 3 + Mem 0       + Dir + IOP + PCA 0 1     + GP  (Hard QBB 0)
 QBB 1 = CPU 0 1 2 3 + Mem 0       + Dir + IOP + PCA 0 1     + GP  (Hard QBB 1)
 QBB 2 = CPU 0 1 2 3 + Mem 0       + Dir + IOP + PCA         + GP  (Hard QBB 4)
 QBB 3 = CPU 0 1 2 3 + Mem 0       + Dir + IOP + PCA         + GP  (Hard QBB 5)
partition 0
 CPU 0 1 2 3 8 9 10 11
 IOP 0 2
 private memory size is 6 GB
 shared memory size is 4 GB
micro firmware version is T5.4
shared RAM version is 1.4
hose 0 has a standard I/O module
starting console on CPU 0
QBB 0 memory, 4 GB
QBB 1 memory, 4 GB
QBB 2 memory, 4 GB
QBB 3 memory, 4 GB
total memory, 16 GB
probing hose 0, PCI
probing PCI-to-ISA bridge, bus 1
bus 1, slot 0 -- dva -- Floppy
bus 0, slot 1 -- pka -- QLogic ISP10x0
bus 0, slot 2 -- pkb -- QLogic ISP10x0
bus 0, slot 3 -- ewa -- DE500-BA Network Controller
bus 0, slot 15 -- dqa -- Acer Labs M1543C IDE
probing hose 1, PCI
probing hose 2, PCI
bus 0, slot 1 -- fwa -- DEC PCI FDDI
probing hose 3, PCI
```

```
starting console on CPU 1
starting console on CPU 2
starting console on CPU 3
starting console on CPU 8
starting console on CPU 9
starting console on CPU 10
starting console on CPU 11
initializing GCT/FRU at 1fa000
initializing pka pkb ewa fwa dqa
Testing the System
Testing the Disks (read only)
Testing the Network
AlphaServer Console X5.8-2842, built on Apr  6 2000 at 01:43:42
P00>>>
```

This command must be entered from the primary Galaxy console. If the Galaxy partitions have been properly defined, and hardware resources have been properly configured, you should see that the primary CPU in each instance has started.

If one or more consoles fails to initialize, double-check your hardware installation, Galaxy partition definitions, and hardware assignments.

Step 8: Boot the OpenVMS Galaxy

When you have correctly installed the Galaxy firmware and configured the consoles, you can boot the initial Galaxy environment as follows:

For each Galaxy instance:

```
P00>>> B -FL 0,1 DKA100 // or whatever your boot device is.

SYSBOOT> SET GALAXY 1

SYSBOOT> CONTINUE
```

Congratulations! You have created an OpenVMS Galaxy.

10 Creating an OpenVMS Galaxy on AlphaServer ES47/ES80/GS1280 Systems

This chapter describes the process of creating an OpenVMS Galaxy computing environment on AlphaServer ES47/ES80/GS1280 systems.

NOTE Using hard partitions on the ES47/ES80/GS1280 Series requires a minimum of the V6.6 console set. This console is available at the AlphaServer firmware Web site cited in Chapter 1.

Step 1: Choose a Configuration and Determine Hardware Requirements

Unlike previous AlphaServer platforms, on the ES47/ES80/GS1280 Galaxy partitions are set up outside the SRM console and there are no environment variables to set.

OpenVMS Alpha Version 7.3-2 supports the maximum configurations for the AlphaServer systems listed in Table 10-1.

Some shared memory and private memory is used for each partition; the minimum amount of memory is as required by OpenVMS.

Table 10-1 ES47/ES80/GS1280 Configurations

ES47	ES80	GS1280/8	GS1280/16	GS1280/32
2 instances	4 instances with embedded IO	2 instances	4 instances (4 IO7 ports required)	8 4P instances (8 IO7 ports required)
2, 2P SBBs	4, 2P SBBs	1, 8P SBB	2, 8P SBBs	4, 8P SBBs
4 CPUs	8 CPUs	8 CPUs	16 CPUs	32 CPUs

Step 2: Set Up the Hardware

When you have acquired the necessary hardware for your configuration, follow the procedures in the appropriate hardware manuals to assemble it.

Step 3: Create a System Disk

Decide which of the following to use:

- One system disk per instance
- A cluster-common disk

Step 4: Install OpenVMS Alpha

No special installation procedures are required to run OpenVMS Galaxy software. Galaxy functionality is included in the base operating system and can be enabled or disabled using the console command and system parameter values described later in this chapter.

For more information about installing the OpenVMS Alpha operating system, see the *HP OpenVMS Alpha Version 7.3-2 Upgrade and Installation Manual* and any required patches.

Check for current revision numbers and how to obtain firmware patches at the following web location:

`http://h18003.www1.hp.com/alphaserver/gs1280/gs1280_tech.html`

OpenVMS Galaxy Licensing Information

In a Galaxy environment, the OPENVMS-GALAXY license units are checked during system startup and whenever a CPU reassignment between instances occurs.

If you attempt to start a CPU and there are insufficient OPENVMS-GALAXY license units to support it, the CPU remains in the instance's configured set but it is stopped. You can subsequently load the appropriate license units and start the stopped CPU while the system is running.

For additional information on licensing, refer to Appendix C of this manual and the *OpenVMS License Management Utility Manual*.

Step 5: Set Up Partitions

When you have installed the operating system, you can set up soft partitions as shown in the examples in this section.

AlphaServer GS1280 Setup of a 32P Hard Partition with Subpartitions

This example creates three soft partitions in a single hard partition on a 32P GS1280. The first partition comprises the first two 8P drawers. The second partition has one 8P drawer, as does the third partition. There are 256 megabytes of shared memory. As seen in the show partition display, the consoles for the various partitions can be accessed via telnet ports. Note that the show partition display will change after a power-on command.

NOTE Use the assign memory command only to set up shared memory.

Part A: Setting Up the Galaxy

```
Welcome - GS1280 Server Manager - V2.1-8
MBM> create partition -hp hp0 255 soft
MBM> create partition -hp hp0 -sp sp0
MBM> create partition -hp hp0 -sp sp1
MBM> create partition -hp hp0 -sp sp2
MBM> assign component -cab 0 -drawer 0 sbb -hp hp0 -sp sp0
MBM> assign component -cab 0 -drawer 1 sbb -hp hp0 -sp sp0
MBM> assign component -cab 0 -drawer 2 sbb -hp hp0 -sp sp1
MBM> assign component -cab 0 -drawer 3 sbb -hp hp0 -sp sp2
MBM> assign mem -hp hp0 256mb -com
MBM> show partition
------------------------------------------------------------------
Hard Partition : HP Name = hp0, HP No.= 0, SP count = 4
Attributes     : max CPUs = 255, SP type = soft, Non-stripe
Physical Memory: 69632MB (68.000GB)

 Community Memory: 256MB (0.250GB)

 Sub Partition: HP Name = hp0, HP No.= 0
                SP Name = sp0, SP No.= 0
                 State = Not Running, Telnet port = 323

 Assigned Memory: unspecified

 CPUs:
     Cab  Drw  CPU   (NS,EW)   PID    Type
      0    0    0    ( 0,0 )    0    Non-primary
      0    0    2    ( 0,1 )    2    Non-primary
      0    0    4    ( 0,2 )    4    Non-primary
      0    0    6    ( 0,3 )    6    Non-primary
      0    0    1    ( 1,0 )    1    Non-primary
      0    0    3    ( 1,1 )    3    Non-primary
      0    0    5    ( 1,2 )    5    Non-primary
      0    0    7    ( 1,3 )    7    Non-primary
      0    1    0    ( 2,0 )    8    Non-primary
      0    1    2    ( 2,1 )   10    Non-primary
      0    1    4    ( 2,2 )   12    Non-primary
      0    1    6    ( 2,3 )   14    Non-primary
      0    1    1    ( 3,0 )    9    Non-primary
      0    1    3    ( 3,1 )   11    Non-primary
      0    1    5    ( 3,2 )   13    Non-primary
      0    1    7    ( 3,3 )   15    Non-primary

 IOPs:
           SBB                              PCI Drawer
    Cab  Drw  IOP   (NS,EW)            Cab  Drw  IOR
     0    0    0    ( 0,0 ) ---------  2    0    0
     0    0    2    ( 0,1 )
     0    0    4    ( 0,2 )
     0    0    6    ( 0,3 )
     0    0    1    ( 1,0 )
     0    0    3    ( 1,1 )
     0    0    5    ( 1,2 ) ---------  1    4    0
     0    0    7    ( 1,3 )
     0    1    0    ( 2,0 ) ---------  2    1    0
     0    1    2    ( 2,1 )
     0    1    4    ( 2,2 )
     0    1    6    ( 2,3 )
     0    1    1    ( 3,0 )
```

```
     0    1    3    ( 3,1 )
     0    1    5    ( 3,2 )
     0    1    7    ( 3,3 )

 Sub Partition: HP Name = hp0, HP No.= 0
                SP Name = sp1, SP No.= 1
                 State = Not Running, Telnet port = 324

 Assigned Memory: unspecified

 CPUs:
     Cab  Drw  CPU   (NS,EW)   PID    Type
      0    2    0    ( 0,4 )    0    Non-primary
      0    2    2    ( 0,5 )    2    Non-primary
      0    2    4    ( 0,6 )    4    Non-primary
      0    2    6    ( 0,7 )    6    Non-primary
      0    2    1    ( 1,4 )    1    Non-primary
      0    2    3    ( 1,5 )    3    Non-primary
      0    2    5    ( 1,6 )    5    Non-primary
      0    2    7    ( 1,7 )    7    Non-primary
 IOPs:
            SBB                          PCI Drawer
     Cab  Drw  IOP   (NS,EW)           Cab  Drw  IOR
      0    2    0    ( 0,4 ) ---------  2    2    0
      0    2    2    ( 0,5 )
      0    2    4    ( 0,6 )
      0    2    6    ( 0,7 )
      0    2    1    ( 1,4 )
      0    2    3    ( 1,5 )
      0    2    5    ( 1,6 )
      0    2    7    ( 1,7 )

Sub Partition: HP Name = hp0, HP No.= 0
               SP Name = sp2, SP No.= 2
                State = Not Running, Telnet port = 325

 Assigned Memory: unspecified

 CPUs:
     Cab  Drw  CPU   (NS,EW)   PID    Type
      0    3    0    ( 2,4 )    8    Non-primary
      0    3    2    ( 2,5 )   10    Non-primary
      0    3    4    ( 2,6 )   12    Non-primary
      0    3    6    ( 2,7 )   14    Non-primary
      0    3    1    ( 3,4 )    9    Non-primary
      0    3    3    ( 3,5 )   11    Non-primary
      0    3    5    ( 3,6 )   13    Non-primary
      0    3    7    ( 3,7 )   15    Non-primary


 IOPs:
            SBB                          PCI Drawer
     Cab  Drw  IOP   (NS,EW)           Cab  Drw  IOR
      0    3    0    ( 2,4 ) ---------  2    3    0
      0    3    2    ( 2,5 )
      0    3    4    ( 2,6 )
      0    3    6    ( 2,7 )
      0    3    1    ( 3,4 )
      0    3    3    ( 3,5 )
      0    3    5    ( 3,6 )
      0    3    7    ( 3,7 )
Sub Partition: HP Name = hp0, HP No.= 0
               SP Name = Free_Pool, SP No.= 255
               State = Not Running
 Free Memory: 0MB (0.000GB)
 CPUs: None
```

```
 IOPs: None
MBM> power on -all
 [...]
```

Part B: Output from Instance 0:

```
~PCO-I-(pco_01) Powering on partition. HP: hp0
starting console on CPU 0
initialized idle PCB
initializing semaphores
initializing heap
initial heap 700c0
memory low limit = 54c000 heap = 700c0, 1fffc0
initializing driver structures
initializing idle process PID
initializing file system
initializing timer data structures
lowering IPL
CPU 0 speed is 1150 MHz
create dead_eater
create poll
create timer
create powerup
entering idle loop
access NVRAM
Get Partition DB
hpcount = 1, spcount = 4, ev7_count = 32, io7_count = 5
hard_partition = 0IO7-100 (Pass 3) at PID 8
IO7 North port speed is 191 MHz
Hose 32 - 33 MHz PCI
Hose 33 - 66 MHz PCI
Hose 34 - 66 MHz PCI
Hose 35 - 4X AGP
IO7-100 (Pass 3) at PID 0
IO7 North port speed is 191 MHz
Hose 0 - 33 MHz PCI
Hose 1 - 66 MHz PCI
Hose 2 - 66 MHz PCI
Hose 3 - 4X AGP
IO7-100 (Pass 3) at PID 5
IO7 North port speed is 191 MHz
Hose 20 - 33 MHz PCI
Hose 21 - 33 MHz PCI
Hose 22 - 33 MHz PCI
Hose 23 - 4X AGP
0 sub-partition 0:   start:00000000 00000000   size:00000000 80000000
PID 0 console memory base: 0, 2 GB
1 sub-partition 0:   start:00000004 00000000   size:00000000 80000000
PID 1 memory: 400000000, 2 GB
2 sub-partition 0:   start:00000008 00000000   size:00000000 80000000
PID 2 memory: 800000000, 2 GB
3 sub-partition 0:   start:0000000c 00000000   size:00000000 80000000
PID 3 memory: c00000000, 2 GB
4 sub-partition 0:   start:00000020 00000000   size:00000000 80000000
PID 4 memory: 2000000000, 2 GB
5 sub-partition 0:   start:00000024 00000000   size:00000000 80000000
PID 5 memory: 2400000000, 2 GB
6 sub-partition 0:   start:00000028 00000000   size:00000000 80000000
PID 6 memory: 2800000000, 2 GB
7 sub-partition 0:   start:0000002c 00000000   size:00000000 80000000
PID 7 memory: 2c00000000, 2 GB
8 sub-partition 0:   start:00000040 00000000   size:00000000 80000000
PID 8 memory: 4000000000, 2 GB
9 sub-partition 0:   start:00000044 00000000   size:00000000 80000000
```

```
PID 9 memory: 4400000000, 2 GB
10 sub-partition 0:   start:00000048 00000000   size:00000000 80000000
PID 10 memory: 4800000000, 2 GB
11 sub-partition 0:   start:0000004c 00000000   size:00000000 80000000
PID 11 memory: 4c00000000, 2 GB
12 sub-partition 0:   start:00000060 00000000   size:00000000 80000000
PID 12 memory: 6000000000, 2 GB
13 sub-partition 0:   start:00000064 00000000   size:00000000 80000000
PID 13 memory: 6400000000, 2 GB
14 sub-partition 0:   start:00000068 00000000   size:00000000 80000000
PID 14 memory: 6800000000, 2 GB
15 sub-partition 0:   start:0000006c 00000000   size:00000000 78000000
PID 15 memory: 6c00000000, 1.875 GB
0 sub-partition 1:   start:00000080 00000000   size:00000000 80000000
1 sub-partition 1:   start:00000084 00000000   size:00000000 80000000
2 sub-partition 1:   start:00000088 00000000   size:00000000 80000000
3 sub-partition 1:   start:0000008c 00000000   size:00000000 80000000
4 sub-partition 1:   start:000000a0 00000000   size:00000000 80000000
5 sub-partition 1:   start:000000a4 00000000   size:00000000 80000000
6 sub-partition 1:   start:000000a8 00000000   size:00000000 80000000
7 sub-partition 1:   start:000000ac 00000000   size:00000000 7c000000
0 sub-partition 2:   start:000000c0 00000000   size:00000000 80000000
1 sub-partition 2:   start:000000c4 00000000   size:00000000 80000000
2 sub-partition 2:   start:000000c8 00000000   size:00000001 00000000
3 sub-partition 2:   start:000000cc 00000000   size:00000001 00000000
4 sub-partition 2:   start:000000e0 00000000   size:00000000 80000000
5 sub-partition 2:   start:000000e4 00000000   size:00000000 80000000
6 sub-partition 2:   start:000000e8 00000000   size:00000000 80000000
7 sub-partition 2:   start:000000ec 00000000   size:00000000 7c000000
0 community 0:   start:0000006c 78000000   size:00000000 08000000
1 community 0:   start:000000ac 7c000000   size:00000000 04000000
2 community 0:   start:000000ec 7c000000   size:00000000 04000000
total memory, 31.875 GB
probe I/O subsystem
probing hose 0, PCI
probing PCI-to-PCI bridge, hose 0 bus 2
do not use secondary IDE channel on CMD controller
bus 2, slot 0, function 0 -- usba -- USB
bus 2, slot 0, function 1 -- usbb -- USB
bus 2, slot 0, function 2 -- usbc -- USB
bus 2, slot 0, function 3 -- usbd -- USB
bus 2, slot 1 -- dqa -- CMD 649 PCI-IDE
bus 2, slot 2 -- pka -- Adaptec AIC-7892
probing hose 1, PCI
bus 0, slot 1, function 0 -- pkb -- Adaptec AIC-7899
bus 0, slot 1, function 1 -- pkc -- Adaptec AIC-7899
probing hose 2, PCI
probing PCI-to-PCI bridge, hose 2 bus 2
bus 2, slot 4 -- eia -- DE602-B*
bus 2, slot 5 -- eib -- DE602-B*
bus 0, slot 2 -- pga -- FCA-2354
probing hose 3, PCI
probing hose 20, PCI
probing PCI-to-PCI bridge, hose 20 bus 2
do not use secondary IDE channel on CMD controller
bus 2, slot 0, function 0 -- usbe -- USB
bus 2, slot 0, function 1 -- usbf -- USB
bus 2, slot 0, function 2 -- usbg -- USB
bus 2, slot 0, function 3 -- usbh -- USB
bus 2, slot 1 -- dqb -- CMD 649 PCI-IDE
bus 2, slot 2 -- pkd -- Adaptec AIC-7892
probing hose 21, PCI
bus 0, slot 2 -- pgb -- KGPSA-C
probing hose 22, PCI
```

```
probing PCI-to-PCI bridge, hose 22 bus 2
bus 2, slot 4 -- eic -- DE602-AA
bus 2, slot 5 -- eid -- DE602-AA
probing hose 23, PCI
probing hose 32, PCI
probing PCI-to-PCI bridge, hose 32 bus 2
do not use secondary IDE channel on CMD controller
bus 2, slot 0, function 0 -- usbi -- USB
bus 2, slot 0, function 1 -- usbj -- USB
bus 2, slot 0, function 2 -- usbk -- USB
bus 2, slot 0, function 3 -- usbl -- USB
bus 2, slot 1 -- dqc -- CMD 649 PCI-IDE
bus 2, slot 2 -- pke -- Adaptec AIC-7892
probing hose 33, PCI
bus 0, slot 1, function 0 -- pkf -- Adaptec AIC-7899
bus 0, slot 1, function 1 -- pkg -- Adaptec AIC-7899
probing hose 34, PCI
probing PCI-to-PCI bridge, hose 34 bus 2
bus 2, slot 4 -- eie -- DE602-B*
bus 2, slot 5 -- eif -- DE602-B*
bus 0, slot 2 -- pgc -- FCA-2354
probing hose 35, PCI
starting drivers
Starting secondary CPU 1 at address 400030000
Starting secondary CPU 2 at address 800030000
Starting secondary CPU 3 at address c00030000
Starting secondary CPU 4 at address 2000030000
Starting secondary CPU 5 at address 2400030000
Starting secondary CPU 6 at address 2800030000
Starting secondary CPU 7 at address 2c00030000
Starting secondary CPU 8 at address 4000030000
Starting secondary CPU 9 at address 4400030000
Starting secondary CPU 10 at address 4800030000
Starting secondary CPU 11 at address 4c00030000
Starting secondary CPU 12 at address 6000030000
Starting secondary CPU 13 at address 6400030000
Starting secondary CPU 14 at address 6800030000
Starting secondary CPU 15 at address 6c00030000
initializing GCT/FRU.......................................................
..................... at 54c000
Initializing dqa dqb dqc eia eib eic eid eie eif pka pkb pkc pkd pke pkf
 pkg pga pgb  pgc
AlphaServer Console T6.5-14, built on Jun 20 2003 at 14:52:48
P00>>>
```

Set environment variables separately for each partition:

```
P00>>> set ei*mode twi
P00>>> set bootdef_dev dka0
```

Part C: Output from Instance 1:

```
~PCO-I-(pco_01) Powering on partition. HP: hp0
starting console on CPU 16
console physical memory base is 8000000000
initialized idle PCB
initializing semaphores
initializing heap
initial heap 700c0
memory low limit = 54c000 heap = 700c0, 1fffc0
initializing driver structures
initializing idle process PID
initializing file system
initializing timer data structures
lowering IPL
```

```
CPU 16 speed is 1150 MHz
create dead_eater
create poll
create timer
create powerup
entering idle loop
access NVRAM
Get Partition DB
hpcount = 1, spcount = 4, ev7_count = 32, io7_count = 5
hard_partition = 0
IO7-100 (Pass 3) at PID 10
IO7 North port speed is 191 MHz
Hose 64 - 33 MHz PCI

Hose 65 - 66 MHz PCI
Hose 66 - 66 MHz PCI
Hose 67 - 4X AGP
0 sub-partition 0:   start:00000000 00000000   size:00000000 80000000
1 sub-partition 0:   start:00000004 00000000   size:00000000 80000000
2 sub-partition 0:   start:00000008 00000000   size:00000000 80000000
3 sub-partition 0:   start:0000000c 00000000   size:00000000 80000000
4 sub-partition 0:   start:00000020 00000000   size:00000000 80000000
5 sub-partition 0:   start:00000024 00000000   size:00000000 80000000
6 sub-partition 0:   start:00000028 00000000   size:00000000 80000000
7 sub-partition 0:   start:0000002c 00000000   size:00000000 80000000
8 sub-partition 0:   start:00000040 00000000   size:00000000 80000000
9 sub-partition 0:   start:00000044 00000000   size:00000000 80000000
10 sub-partition 0:   start:00000048 00000000   size:00000000 80000000
11 sub-partition 0:   start:0000004c 00000000   size:00000000 80000000
12 sub-partition 0:   start:00000060 00000000   size:00000000 80000000
13 sub-partition 0:   start:00000064 00000000   size:00000000 80000000
14 sub-partition 0:   start:00000068 00000000   size:00000000 80000000
15 sub-partition 0:   start:0000006c 00000000   size:00000000 78000000

0 sub-partition 1:   start:00000080 00000000   size:00000000 80000000
PID 16 console memory base: 8000000000, 2 GB
1 sub-partition 1:   start:00000084 00000000   size:00000000 80000000
PID 17 memory: 8400000000, 2 GB
2 sub-partition 1:   start:00000088 00000000   size:00000000 80000000
PID 18 memory: 8800000000, 2 GB
3 sub-partition 1:   start:0000008c 00000000   size:00000000 80000000
PID 19 memory: 8c00000000, 2 GB
4 sub-partition 1:   start:000000a0 00000000   size:00000000 80000000
PID 20 memory: a000000000, 2 GB
5 sub-partition 1:   start:000000a4 00000000   size:00000000 80000000
PID 21 memory: a400000000, 2 GB
6 sub-partition 1:   start:000000a8 00000000   size:00000000 80000000
PID 22 memory: a800000000, 2 GB
7 sub-partition 1:   start:000000ac 00000000   size:00000000 7c000000
PID 23 memory: ac00000000, 1.938 GB
0 sub-partition 2:   start:000000c0 00000000   size:00000000 80000000
1 sub-partition 2:   start:000000c4 00000000   size:00000000 80000000
2 sub-partition 2:   start:000000c8 00000000   size:00000001 00000000
3 sub-partition 2:   start:000000cc 00000000   size:00000001 00000000
4 sub-partition 2:   start:000000e0 00000000   size:00000000 80000000
5 sub-partition 2:   start:000000e4 00000000   size:00000000 80000000
6 sub-partition 2:   start:000000e8 00000000   size:00000000 80000000
7 sub-partition 2:   start:000000ec 00000000   size:00000000 7c000000
0 community 0:   start:0000006c 78000000   size:00000000 08000000
1 community 0:   start:000000ac 7c000000   size:00000000 04000000
2 community 0:   start:000000ec 7c000000   size:00000000 04000000
total memory, 15.938 GB
waiting for GCT/FRU at 54c000 by CPU 0
probe I/O subsystem
probing hose 64, PCI
```

```
probing PCI-to-PCI bridge, hose 64 bus 2
do not use secondary IDE channel on CMD controller
bus 2, slot 0, function 0 -- usba -- USB
bus 2, slot 0, function 1 -- usbb -- USB
bus 2, slot 0, function 2 -- usbc -- USB
bus 2, slot 0, function 3 -- usbd -- USB
bus 2, slot 1 -- dqa -- CMD 649 PCI-IDE
bus 2, slot 2 -- pka -- Adaptec AIC-7892
probing hose 65, PCI
bus 0, slot 1, function 0 -- pkb -- Adaptec AIC-7899
bus 0, slot 1, function 1 -- pkc -- Adaptec AIC-7899
probing hose 66, PCIprobing PCI-to-PCI bridge, hose 66 bus 2
bus 2, slot 4 -- eia -- DE602-B*
bus 2, slot 5 -- eib -- DE602-B*
bus 0, slot 2 -- pga -- FCA-2354
probing hose 67, PCI
starting drivers
Starting secondary CPU 17 at address 8400030000
Starting secondary CPU 18 at address 8800030000
Starting secondary CPU 19 at address 8c00030000
Starting secondary CPU 20 at address a000030000
Starting secondary CPU 21 at address a400030000
Starting secondary CPU 22 at address a800030000
Starting secondary CPU 23 at address ac00030000
initializing GCT/FRU to 54c000
Initializing dqa eia eib pka pkb pkc pga
AlphaServer Console T6.5-14, built on Jun 20 2003 at 14:52:48
P16>>>set ei*mode twi
P16>> set bootdef_dev dka0
```

Part D: Output from Instance 2:

```
~PCO-I-(pco_01) Powering on partition. HP: hp0
starting console on CPU 24
console physical memory base is c000000000
initialized idle PCB
initializing semaphores
initializing heap
initial heap 700c0
memory low limit = 54c000 heap = 700c0, 1fffc0
initializing driver structures
initializing idle process PID
initializing file system
initializing timer data structures
lowering IPL
CPU 24 speed is 1150 MHz
create dead_eater
create poll
create timer
create powerup
entering idle loop
access NVRAM
Get Partition DB
hpcount = 1, spcount = 4, ev7_count = 32, io7_count = 5
hard_partition = 0
IO7-100 (Pass 3) at PID 18
IO7 North port speed is 191 MHz
Hose 96 - 33 MHz PCI
Hose 97 - 66 MHz PCI
Hose 98 - 66 MHz PCI
Hose 99 - 4X AGP
0 sub-partition 0:   start:00000000 00000000   size:00000000 80000000
1 sub-partition 0:   start:00000004 00000000   size:00000000 80000000
2 sub-partition 0:   start:00000008 00000000   size:00000000 80000000
```

```
3 sub-partition 0:   start:0000000c 00000000   size:00000000 80000000
4 sub-partition 0:   start:00000020 00000000   size:00000000 80000000
5 sub-partition 0:   start:00000024 00000000   size:00000000 80000000
6 sub-partition 0:   start:00000028 00000000   size:00000000 80000000
7 sub-partition 0:   start:0000002c 00000000   size:00000000 80000000
8 sub-partition 0:   start:00000040 00000000   size:00000000 80000000
9 sub-partition 0:   start:00000044 00000000   size:00000000 80000000
10 sub-partition 0:   start:00000048 00000000   size:00000000 80000000
11 sub-partition 0:   start:0000004c 00000000   size:00000000 80000000
12 sub-partition 0:   start:00000060 00000000   size:00000000 80000000
13 sub-partition 0:   start:00000064 00000000   size:00000000 80000000
14 sub-partition 0:   start:00000068 00000000   size:00000000 80000000
15 sub-partition 0:   start:0000006c 00000000   size:00000000 78000000
0 sub-partition 1:   start:00000080 00000000   size:00000000 80000000
1 sub-partition 1:   start:00000084 00000000   size:00000000 80000000
2 sub-partition 1:   start:00000088 00000000   size:00000000 80000000
3 sub-partition 1:   start:0000008c 00000000   size:00000000 80000000
4 sub-partition 1:   start:000000a0 00000000   size:00000000 80000000
5 sub-partition 1:   start:000000a4 00000000   size:00000000 80000000
6 sub-partition 1:   start:000000a8 00000000   size:00000000 80000000
7 sub-partition 1:   start:000000ac 00000000   size:00000000 7c000000
0 sub-partition 2:   start:000000c0 00000000   size:00000000 80000000
PID 24 console memory base: c000000000, 2 GB
1 sub-partition 2:   start:000000c4 00000000   size:00000000 80000000
PID 25 memory: c400000000, 2 GB
2 sub-partition 2:   start:000000c8 00000000   size:00000001 00000000
PID 26 memory: c800000000, 4 GB
3 sub-partition 2:   start:000000cc 00000000   size:00000001 00000000
PID 27 memory: cc00000000, 4 GB
4 sub-partition 2:   start:000000e0 00000000   size:00000000 80000000
PID 28 memory: e000000000, 2 GB
5 sub-partition 2:   start:000000e4 00000000   size:00000000 80000000
PID 29 memory: e400000000, 2 GB
6 sub-partition 2:   start:000000e8 00000000   size:00000000 80000000
PID 30 memory: e800000000, 2 GB
7 sub-partition 2:   start:000000ec 00000000   size:00000000 7c000000
PID 31 memory: ec00000000, 1.938 GB
0 community 0:   start:0000006c 78000000   size:00000000 08000000
1 community 0:   start:000000ac 7c000000   size:00000000 04000000
2 community 0:   start:000000ec 7c000000   size:00000000 04000000
total memory, 19.938 GB
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
waiting for GCT/FRU at 54c000 by CPU 0
probe I/O subsystem
probing hose 96, PCI
probing PCI-to-PCI bridge, hose 96 bus 2
do not use secondary IDE channel on CMD controller
```

```
bus 2, slot 0, function 0 -- usba -- USB
bus 2, slot 0, function 1 -- usbb -- USB
bus 2, slot 0, function 2 -- usbc -- USB
bus 2, slot 0, function 3 -- usbd -- USB
bus 2, slot 1 -- dqa -- CMD 649 PCI-IDE
bus 2, slot 2 -- pka -- Adaptec AIC-7892
probing hose 97, PCI
bus 0, slot 1, function 0 -- pkb -- Adaptec AIC-7899
bus 0, slot 1, function 1 -- pkc -- Adaptec AIC-7899
probing hose 98, PCI
probing PCI-to-PCI bridge, hose 98 bus 2
bus 2, slot 4 -- eia -- DE602-B*
bus 2, slot 5 -- eib -- DE602-B*
bus 0, slot 2 -- pga -- FCA-2354
probing hose 99, PCI
starting drivers
Starting secondary CPU 25 at address c400030000
Starting secondary CPU 26 at address c800030000
Starting secondary CPU 27 at address cc00030000
Starting secondary CPU 28 at address e000030000
Starting secondary CPU 29 at address e400030000
Starting secondary CPU 30 at address e800030000
Starting secondary CPU 31 at address ec00030000
initializing GCT/FRU to 54c000
Initializing dqa eia eib pka pkb pkc pga
AlphaServer Console T6.5-14, built on Jun 20 2003 at 14:52:48
P24>>>set ei*mode two
P24>>>set bootdef_dev dka100
```

Step 6: Boot the OpenVMS Galaxy

Changing the partition setup may affect console environment variable values; check to ensure they are correct. To ensure that AUTOGEN reboots correctly when it needs to reboot the system after an initial installation and after a system failure or operator-requested reboot, set the BOOTDEF_DEV and BOOT_OSFLAGS variables on each of your Galaxy consoles before booting.

When the OpenVMS system is booted with Galaxy enabled, each soft partition can run a separate instance of the operating system as a Galaxy member.

At a point in the boot process, the instance will attempt to join the Galaxy configuration. If no Galaxy exists, the attempt triggers the creation of a Galaxy, generating a new Galaxy ID and initializing the structures in shared memory that all members in the resulting Galaxy will use. If a Galaxy does exist, the instance joins, connecting to the shared memory constructs and, through them, to the other member instances.

For a Galaxy instance on the ES47/ES80/GS1280:

- There can be only one primary CPU in any 2P building block.
- Either CPU of a 2P building block can be a primary in a Galaxy instance.
- Each Galaxy requires an IO port.
- Up to 8 Galaxy partitions are supported per hard partition.

When you have correctly installed the Galaxy firmware and configured the consoles, you can boot the initial Galaxy environment as follows:

For each Galaxy instance:

```
P00>>> B -FL 0,1 DKA100 // or whatever your boot device is.

SYSBOOT> SET GALAXY 1

SYSBOOT> CONTINUE
```

Congratulations! You have created an OpenVMS Galaxy.

11 Using a Single-Instance Galaxy on an Alpha System

Since OpenVMS Alpha Version 7.2, it has been possible to run a single-instance Galaxy on any Alpha platform *except for the ES45*. This capability allows early adopters to evaluate OpenVMS Galaxy features and, most important, to develop and test Galaxy-aware applications without incurring the expense of setting up a full-scale Galaxy computing environment on a system capable of running multiple instances of OpenVMS (for example, an AlphaServer 8400).

A single-instance Galaxy running on an Alpha system is not an emulator. It is OpenVMS Galaxy code with Galaxy interfaces and underlying operating system functions. All Galaxy APIs are present in a single-instance Galaxy (for example, resource management, shared memory access, event notification, locking for synchronization, and shared memory for global sections).

Any application that is run on a single-instance Galaxy exercises the identical operating system code on a multiple-instance Galaxy system. This is accomplished by creating the configuration file SYS$SYSTEM:GLX$GCT.BIN, which OpenVMS reads into memory. On a Galaxy platform (for example, an AlphaServer 8400), the console places configuration data in memory for OpenVMS to use. Once the configuration data is in memory, regardless of its origin, OpenVMS boots as a Galaxy instance.

Creating a Single-Instance Galaxy with GCU

To use the Galaxy Configuration Utility (GCU) to create a single-instance Galaxy on an Alpha system, use the following procedure:

1. Run the GCU on the OpenVMS Alpha system on which you want to use the single-instance Galaxy.
2. If the GCU is run on a non-Galaxy system, it asks you if you want to create a single-instance Galaxy. Click on **OK.**
3. The GCU prompts next for the amount of memory to designate as shared memory. Enter any value that is a multiple of 8 MB. Note that you must specify at least 8 MB of shared memory if you want to boot as a Galaxy instance.
4. Once the GCU has displayed the configuration, it has already written the file GLX$GCT.BIN to the current directory. You can exit the GCU at this point. If you made a mistake or want to alter the configuration, you can close the current model and repeat the process.

Rebooting as a Galaxy Instance

To reboot the system as a Galaxy instance:

1. Copy the GLX$GCT.BIN file to SYS$SYSROOT:[SYSEXE]GLX$GCT.BIN.

2. Shut down the system.
3. Reboot with a conversational boot command. For example:

```
>>> B -FL 0,1 device
```

4. Enter the following commands:

```
SYSBOOT> SET GALAXY 1
SYSBOOT> CONTINUE
```

5. Add GALAXY=1 to SYS$SYSTEM:MODPARAMS.DAT.

12 OpenVMS Galaxy Tips and Techniques

This chapter contains information that OpenVMS Engineering has found useful in creating and running OpenVMS Galaxy environments.

System Auto-Action

Upon system power-up, if the AUTO_ACTION console environment variable is set to BOOT or RESTART for instance 0, then the GALAXY command is automatically issued and instance 0 attempts to boot.

The setting of AUTO_ACTION in the console environment variables for the other instances dictates their behavior when entering the GALAXY command (whether it is entered automatically or by the user from the console).

To set up your system for this feature, you must set the console environment variable AUTO_ACTION to RESTART or BOOT on each instance. Make sure to specify appropriate values for the BOOT_OSFLAGS and BOOTDEF_DEV environment variables for each instance.

Changing Console Environment variables

Once you have established the initial set of LP_* environment variables for OpenVMS Galaxy operation and booted your system, changing environment variable values requires that you first reinitialize the system, change the values, and reinitialize again. Wrapping the changes between INIT commands is required to properly propagate the new values to all partitions.

NOTE For AlphaServer 4100 systems no INIT command is needed to start, but you must change these variables on both instances.

Console Hints

The AlphaServer 8400 and 8200 systems were designed before the Galaxy Software Architecture, so the OpenVMS Galaxy console firmware and system operations must accommodate a few restrictions.

The following list briefly describes some issues to be aware of and some things to avoid doing:

- Do not set the BOOT_RESET environment variable to 1. This causes each secondary console to reset the bus before booting, which resets all previously booted partitions. Remember that OpenVMS Galaxy partitions share the hardware.

- Be patient. Console initialization and system rebooting can take several minutes.
- **Do not attempt to abort a firmware update process!**

  This can hang your system.
- When updating console firmware, update *all CPUs* at the same time.

  You cannot run two different types of CPUs or two different firmware revisions. If you fail to provide consistent firmware revisions, the system hangs on power-up.
- Never enter the GALAXY command from a secondary console. This reinitializes the system, and you need to start over from the primary console.

Turning Off Galaxy Mode

If you want to turn off OpenVMS Galaxy software, change the LP_COUNT environment variable as follows and enter the following commands:

```
>>> SET LP_COUNT 0    ! Return to monolithic SMP config
>>> INIT              ! Return to single SMP console
>>> B -fl 0,1 device  ! Stop at SYSBOOT
SYSBOOT> SET GALAXY 0
SYSBOOT> CONTINUE
```

13 OpenVMS Galaxy Configuration Utility

The Galaxy Configuration Utility (GCU) is a DECwindows Motif application that allows system managers to configure and manage an OpenVMS Galaxy system from a single workstation window.

Using the GCU, system managers can:

- Display the active Galaxy configuration.
- Reassign resources among Galaxy instances.
- View resource-specific characteristics.
- Shut down or reboot one or more Galaxy instances.
- Invoke additional management tools.
- Create and engage Galaxy configuration models.
- Create a single-instance Galaxy on any Alpha system (for software development on non-Galaxy hardware platforms).
- View the online Galaxy documentation.
- Determine hot-swap characteristics of the current hardware platform.

The GCU resides in the SYS$SYSTEM directory along with a small number of files containing configuration information.

The GCU consists of the following files:

File	Description
SYS$SYSTEM:GCU.EXE	GCU executable image
SYS$MANAGER:GCU.DAT	Optional DECwindows resource file
SYS$MANAGER:GALAXY.GCR	Galaxy Configuration Ruleset
SYS$MANAGER:GCU$ACTIONS.COM	System management procedures
SYS$MANAGER:*xxx*.GCM	User-defined configuration models
SYS$HELP:GALAXY_GUIDE.DECW$BOOK	Online help in Bookreader form

The GCU can be run from any Galaxy instance. If the system does not directly support graphics output, then the DECwindows display can be set to an external workstation or suitably configured PC. However, the GCU application itself must always run on the Galaxy system.

When the GCU is started, it loads any customizations found in its resource file (GCU.DAT); then it loads the Galaxy Configuration Ruleset (GALAXY.GCR). The ruleset file contains statements that determine the way the GCU displays the various system components, and includes rules that govern the ways in which users can interact with the configuration display. Users do not typically alter the ruleset file unless they are well versed in its structure or are directed to do so by an HP Services engineer.

After the GCU display becomes visible, the GCU determines whether the system is currently configured as an OpenVMS Galaxy or as a single-instance Galaxy on a non-Galaxy platform. If the system is configured as a Galaxy, the GCU displays the active Galaxy configuration model. The main observation window displays a hierarchical view of the Galaxy. If the system has not yet been configured as a Galaxy, the GCU prompts you

as to whether or not to create a single-instance Galaxy. Note that the GCU can create a single-instance Galaxy on any Alpha system, but multiple-instance OpenVMS Galaxy environments are created by using console commands and console environment variables.

Once the Galaxy configuration model is displayed, users can either interact with the active model or take the model off line and define specific configurations for later use. The following sections discuss these functions in greater detail.

GCU Tour

The GCU can perform three types of operations:

- Create Galaxy configuration models or a single-instance Galaxy (Section Creating Galaxy Configuration Models).
- Observe active Galaxy resources (Section Observation).
- Interact with active Galaxy resource configurations (Section Interaction).

Most GCU operations are organized around the main observation window and its hierarchical display of Galaxy components. The observation window provides a porthole into a very large space. The observation window can be panned and zoomed as needed to observe part of or all of the entire Galaxy configuration. The main toolbar contains a set of buttons that control workspace zoom operations. Workspace panning is controlled by the horizontal and vertical scrollbars; workspace sliding is achieved by holding down the middle mouse button as you drag the workspace around. This assumes you have a three-button mouse.

The various GCU operations are invoked from pull-down or pop-up menu functions. General operations such as opening and closing files, and invoking external tools, are accomplished using the main menu bar entries. Operations specific to individual Galaxy components are accomplished using pop-up menus that appear whenever you click the right mouse button on a component displayed in the observation window.

In response to many operations, the GCU displays additional dialog boxes containing information, forms, editors, or prompts. Error and information responses are displayed in pop-up dialog boxes or inside the status bar along the bottom of the window, depending on the severity of the error and importance of the message.

Creating Galaxy Configuration Models

You can use the GCU to create Galaxy configuration models and a single-instance Galaxy on an Alpha system.

When viewing the active Galaxy configuration model, direct manipulation of display objects (components) may alter the running configuration. For example, dragging a CPU from its current location and dropping it on top of a different instance component invokes a management action procedure that reassigns the selected CPU to the new instance. At certain times this may be a desirable operation; however, in other situations you might want to reconfigure your Galaxy all at once rather than by individual component. To accomplish this, you must create an offline Galaxy configuration model.

To create a Galaxy configuration model, you must start with an existing model, typically the active one, alter it in some manner, and save it in a file.

Starting from the active Galaxy Configuration Model:

1. Press the ENGAGE button so that the model becomes DISENGAGED. The button should turn from red to white, and its appearance should be popped outward. When disengaged, all CPU components in the display turn red as an indication that they are no longer engaged. Do not panic, they have not been shut down.
2. Alter the CPU assignments by dragging and dropping individual CPUs onto the instances on which you want to assign them.
3. When finished, you can either reengage the model or save the model in a file for later use. Whenever you reengage a model, regardless of whether the model was derived from the active model or from a file-based model, the GCU compares the active system configuration with the configuration proposed by the model. It then provides a summary of management actions that would need to be performed to reassign the system to the new model. If the user approves of the actions, the GCU commences with execution of the required management actions and the resulting model is displayed as the active and engaged model.

The reason for creating offline models is to allow significant configuration changes to be automated. For example, you can create models representing the desired Galaxy configuration at different times and then engage the models interactively by following this procedure.

Observation

The GCU can display the single active Galaxy configuration model, or any number of offline Galaxy configuration models. Each loaded model appears as an item in the Model menu on the toolbar. You can switch between models by clicking the desired menu item.

The active model is always named GLX$ACTIVE.GCM. When the active model is first loaded, a file by this name exists briefly as the system verifies the model with the system hardware.

When a model is visible, you can zoom, pan, or slide the display as needed to view Galaxy components. Use the buttons on the left side of the toolbar to control the zoom functions.

The zoom functions include:

Function	Description
Galactic zoom	Zoom to fit the entire component hierarchy into observation window.
Zoom 1:1	Zoom to the component normal scale.
Zoom to region	Zoom to a selected region of the display.
Zoom in	Zoom in by 10 percent.
Zoom out	Zoom out by 10 percent.

Panning is accomplished by using the vertical and horizontal scrollbars. Sliding is done by pressing and holding the middle mouse button and dragging (sliding) the cursor and the image.

Layout Management

The Automatic Layout feature manages the component layout. If you ever need to refresh the layout while in Automatic Layout mode, select the root (topmost) component.

To alter the current layout, select Manual Layout from the Windows menu. In Manual Layout Mode, you can drag and drop components however you like to generate a pleasing structure. Because each component is free from automatic layout constraints, you may need to invest some time in positioning each component, possibly on each of the charts. To make things simpler, you can click the right mouse button on any component and select Layout Subtree to provide automatic layout assistance below that point in the hierarchy.

When you are satisfied with the layout, you must save the current model in a file to retain the manual layout information. The custom layout is used when the model is open. Note that if you select Auto Layout mode, your manual layout is lost for the in-memory model. Also, in order for CPU components to reassign in a visually effective manner, they must perform subtree layout operations below the instance level. For this reason, it is best to limit any manual layout operations to the instance and community levels of the component hierarchy.

OpenVMS Galaxy Charts

The GCU provides six distinct subsets of the model, known as charts. The six charts include:

Chart Name	Shows
Logical Structure	Dynamic resource assignments
Physical Structure	Nonvolatile hardware relationships
CPU Assignment	Simplified view of CPU assignments
Memory Assignment	Memory subsystem components
IOP Assignment	I/O module relationships
Failover Targets	Processor failover assignments

These charts result from enabling or disabling the display of various component types to provide views of sensible subsets of components.

Specific charts may offer functionality that can be provided only for that chart type. For example, reassignment of CPUs requires that the instance components be visible. Because instances are not visible in the Physical Structure or Memory Assignment charts, you can reassign CPUs only in the Logical Structure and CPU Assignment charts.

For more information about charts, see Using the GCU Charts.

Interaction

When viewing the active Galaxy configuration model, you can interact directly with the system components. For example, to reassign a CPU from one instance to another, you can drag and drop a CPU onto the desired instance. The GCU validates the operation and execute an external command action to make the configuration change. Interacting with a model that is not engaged is simply a drawing operation on the offline model, and it has no impact on the running system.

While interacting with Galaxy components, the GCU applies built-in and user-defined rules that prevent misconfiguration and improper management actions. For example, you cannot reassign primary CPUs, and you cannot reassign a CPU to any component other than a Galaxy instance. Either operation will result in an error message on the status bar, and the model will return to its proper configuration. If the attempted operation violates one of the configuration rules, the error message, displayed in red on the status bar, describes the rule that failed.

You can view details for any selected component by clicking the right mouse button and either selecting the Parameters item from the pop-up menu or by selecting Parameters from the Components menu on the main toolbar.

The GCU can shut down or reboot one or more Galaxy instances using the Shutdown or Reboot items on the Galaxy menu. You can enter the various shutdown or reboot parameters can be entered in the Shutdown dialog box. Be sure to specify the CLUSTER_SHUTDOWN option to fully shut down clustered Galaxy instances. The Shutdown dialog box allows you to select any combination of instances, or all instances. The GCU is smart enough to shut down its owner instance last.

Managing an OpenVMS Galaxy with the GCU

Your ability to manage a Galaxy system using the GCU depends on the capabilities of each instance involved in a management operation.

The GCU can be run from any instance in the Galaxy. However, the Galaxy Software Architecture implements a push-model for resource reassignment. This means that, in order to reassign a processor, you must execute the reassign command function on the instance that currently owns the processor. The GCU is aware of this requirement, and attempts to use one or more communications paths to send the reassignment request to the owner instance. DCL is not inherently aware of this requirement; therefore, if you use DCL to reassign resources, you need to use SYSMAN or a separately logged-in terminal to enter the commands on the owner instance.

The GCU favors using SYSMAN, and its underlying SMI_Server processes, to provide command paths to the other instances in the Galaxy. However, the SMI_Server requires that the instances be in a cluster so that the command environment falls within a common security domain. However, Galaxy instances might not be clustered.

If the system cannot provide a suitable command path for the SMI_Server to use, the GCU attempts to use DECnet task-to-task communications. This requires that the participating instances be running DECnet, and that each participating Galaxy instance have a proxy set up for the SYSTEM account.

Independent Instances

You can define a Galaxy system so that one or more instances are not members of the Galaxy sharing community. These are known as **independent instances**, and they are visible to the GCU.

These independent instances can still participate in CPU reassignment. They cannot utilize shared memory or related services.

Isolated Instances

It is possible for an instance to not be clustered, have no proxy account established, and not have DECnet capability. These are known as **isolated instances**. They are visible to the GCU, and you can reassign CPUs to them. The only way to reassign resources from an isolated instance is from the console of the isolated instance.

Required PROXY Access

When the GCU needs to execute a management action, it always attempts to use the SYSMAN utility first. SYSMAN requires that the involved instances be in the same cluster. If this is not the case, the GCU next attempts to use DECnet task-to-task communications. For this to work, the involved instances must each have an Ethernet device, DECnet capability, and suitable proxy access on the target instance.

For example, consider a two-instance configuration that is not clustered. If instance 0 were running the GCU and the user attempts to reassign a CPU from instance 1 to instance 0, the actual reassignment command must be executed on instance 1. To do this, the GCU's action procedures in the file SYS$MANAGER:GCU$ACTIONS.COM attempts to establish a DECnet task-to-task connection to the SYSTEM account on instance 1. This requires that instance 1 has granted proxy access to the SYSTEM account of instance 0. Using the established connection, the action procedure on instance 0 passes its parameters to the equivalent action procedure on instance 1, which now treats the operation as a local operation.

The GCU action procedures assume that they are used by the system manager. Therefore, in the action procedure file SYS$MANAGER:GCU$ACTIONS.COM, the SYSTEM account is used. To grant access to the opposite instances SYSTEM account, the proxy must be set up on instance 1.

To establish proxy access:

1. Enter the following commands at the DCL prompt:

```
$ SET DEFAULT SYS$SYSTEM
$ RUN AUTHORIZE
```

2. If proxy processing is not yet enabled, enable it by entering the following commands:

```
UAF> CREATE/PROXY
UAF> ADD/PROXY instance::SYSTEM SYSTEM
UAF> EXIT
```

Replace *instance* with the name of the instance to which you are granting access. Perform these steps for each of the instances you want to manage from the instance on which you run the GCU. For example, in a typical two-instance Galaxy, if you run the GCU only on instance 0, then you need to add proxy access only on instance 1 for instance 0. If you intend to run the GCU on instance 1 also, then you need to add proxy access on instance 0 for instance 1. In three-instance Galaxy systems, you may need to add proxy access for each combination of instances you want to control. For this reason, always run the GCU from instance 0.

You are not required to use the SYSTEM account. To change the account, you need to edit SYS$MANAGER:GCU$ACTIONS.COM on each involved instance. Locate the line that establishes the task-to-task connection, and replace the SYSTEM account name with one of your choosing.

Note that the selected account must have OPER, SYSPRV, and CMKRNL privileges. You also need to add the necessary proxy access to your instances for this account.

Galaxy Configuration Models

The GCU is a fully programmable display engine. It uses a set of rules to learn the desired characteristics and interactive behaviors of the system components. Using this specialized configuration knowledge, the GCU assembles models that represent the relationships among system components. The GCU obtains information about the current system structure by parsing a configuration structure built by the console firmware. This

structure, called the Galaxy Configuration File, is stored in memory and is updated as needed by firmware and by OpenVMS executive routines to ensure that it accurately reflects the current system configuration and state.

The GCU converts and extends the binary representation of the configuration file into a simple ASCII representation, which it can store in a file as an offline model. The GCU can later reload an offline model and alter the system configuration to match the model. Whether you are viewing the active model or an offline model, you can save the current configuration as an offline Galaxy Configuration Model (.GCM) file.

To make an offline model drive the current system configuration, the model must be loaded and engaged. To engage a model, click the Engage button. The GCU scans the current configuration file, compare it against the model, and create a list of any management actions that are required to engage the model. The GCU presents this list to you for final confirmation. If you approve, the GCU executes the actions, and the model is engaged to reflect the current system configuration and state.

When you disengage a model, the GCU immediately marks the CPUs and instances as off line. You can then arrange the model however you like, and either save the model, or reengage the model. In typical practice, you are likely to have a small number of models that have proved to be useful for your business operations. These can be engaged by a system manager or a suitably privileged user, or through DCL command procedures.

Active Model

The GCU maintains a single active model. This model is always derived from the in-memory configuration file. The configuration file can be from a Galaxy console or from a file-based, single-instance Galaxy on any Alpha system. Regardless of its source, console callbacks maintain the integrity of the file.

The GCU utilizes Galaxy event services to determine when a configuration change has occurred. When a change occurs, the GCU parses the configuration file and updates its active model to reflect the current system. The active model is not saved to a file unless you choose to save it as an offline model. Typically, the active model becomes the basis for creating additional models. When creating models, it is generally best to do so online so that you are sure your offline models can engage when they are needed.

Offline Models

The GCU can load any number of offline Galaxy configuration models and freely switch among them, assuming they were created for the specific system hardware. The model representation is a simple ASCII data definition format.

You should never need to edit a model file in its ASCII form. The GCU models and ruleset adhere to a simple proprietary language known as the Galaxy Configuration Language (GCL). This language continues to evolve as needed to represent new Galaxy innovations. Note this fact if you decide to explore the model and ruleset files directly. If you accidentally corrupt a model, you can always generate another. If you corrupt the ruleset, you may need to download another from the OpenVMS Galaxy web site.

Example: Creating an Offline Model

To create an offline Galaxy configuration model:

1. Boot your Galaxy system, log in to the system account, and run the GCU.
2. By default, the GCU displays the active model.
3. Disengage the active model by clicking the Engage button (it toggles).
4. Assuming your system has a few secondary CPUs, drag and drop some of the CPUs to a different Galaxy instance.

5. Save the model by selecting Save Model from the Model menu. Give the model a suitable name with a .GCM extension. It is useful to give the model a name that denotes the CPU assignments; for example, G1x7.GCM for a system in which instance 0 has 1 CPU and instance 1 has 7 CPUs, or G4x4.GCM for a system with 4 CPUs on each of its two instances. This naming scheme is optional, but be sure to give the file the proper .GCM extension.

   You can create and save as many variations of the model as you like.

To engage an offline model:

1. Run the GCU.
2. By default, the GCU displays the active model. You can close the active model or just leave it.
3. Load the desired model by selecting Open Model from the Model menu.
4. Locate and select the desired model and click OK. The model is loaded and displayed in an offline, disengaged state.
5. Click the Engage button to reengage the model.
6. The GCU displays any management operations required to engage the model. If you approve of the actions, click OK. The GCU performs the management actions, and the model is displayed as active and engaged.

Using the GCU Charts

The GCU contains a considerable amount of configuration data and can grow quite large for complex Galaxy configurations. If the GCU displayed all the information it has about the system, the display would become unreasonably complex. To avoid this problem, the GCU provides Galaxy charts. Charts are a set of masks that control the visibility of the various components, devices, and interconnections. The entire component hierarchy is present, but only the components specified by the selected chart are visible. Selecting a different chart alters the visibility of component subsets.

By default, the GCU provides five preconfigured charts:

- Physical Structure chart (“Physical Structure Chart” on page 123)
- Logical Structure Chart (“Logical Structure Chart” on page 124)
- Memory Assignment Chart (“Memory Assignment Chart” on page 125)
- CPU Assignment Chart (“CPU Assignment Chart” on page 125)
- IOP Assignment Chart (“IOP Assignment Chart” on page 126)
- Failover Target Chart (“Failover Target Chart” on page 126)

Each chart is designed to show a specific component relationship. Some GCU command operations can be performed only within specific charts. For example, you cannot reassign CPUs from within the Physical Structure chart. The Physical Structure chart does not show the Galaxy instance components; you would have no target to drag and drop a CPU on. Similarly, you cannot perform a hot-swap inquiry operation if you are displaying the Logical Structure chart. Device hot-swapping is a physical task that cannot be represented in the logical chart. Because you can modify the charts, the GCU does not restrict its menus and command operations to specific chart selections. In some cases, the GCU displays an informational message to help you select an appropriate chart.

Component Identification and Display Properties

Each component has a unique identifier. This identifier can be a simple sequential number, such as with CPU IDs, a physical backplane slot number, as with I/O adapters, or a physical address, as with memory devices. Each component type is also assigned a shape and color by the GCU. Where possible, the GCU further distinguishes each component using supplementary information it gathers from the running system.

The display properties of each component are assigned within the Galaxy Configuration Ruleset (SYS$MANAGER:GALAXY.GCR). Do not edit this file, except to customize certain display properties, such as window color or display text style.

You can also customize the text that gets displayed about each component. Each component type has a set of statements in the ruleset that determine its appearance, data content, and interaction.

One useful feature is the ability to select which text is displayed in each component type on the screen. The device declaration in the ruleset allows you to specify the text and parameters, which make up the display text statement. A subset of this display text is displayed whenever the zoom scale factor does not allow the full text to be displayed. This subset is known as the mnemonic. The mnemonic can be altered to include any text and parameters.

Physical Structure Chart

The Physical Structure chart describes the physical hardware in the system. The large rectangular component at the top, or root, of the chart represents the physical system cabinet itself. Typically, below the root, you find physical components such as modules, slots, arrays, adapters, and so on. The type of components presented and the depth of the component hierarchy is directly dependent on the level of support provided by the console firmware for each hardware platform. If you are viewing a single-instance Galaxy on any Alpha system, then only a small subset of components can be displayed.

As a general rule, the console firmware presents components only down to the level of configurable devices, typically to the first-level I/O adapter or slightly beyond. It is not a goal of the GCU or of the Galaxy console firmware to map every device, but rather those that are of interest to Galaxy configuration management.

The Physical Structure chart is useful for viewing the entire collection of components in the system; however, it does not display any logical partitioning of the components.

In the Physical Structure chart you can:

- Examine the parameters of any system component.
- Perform a hot-swap inquiry to determine how to isolate a component for repairs.
- Apply an Optimization Overlay to determine whether the hardware platform has specific optimizations that ensures the best performance. For example, multiple-CPU modules may run best if all CPUs residing on a common module are assigned to the same Galaxy instance.
- Shut down or reboot the Galaxy or specific Galaxy instances.

Hardware Root

The topmost component in the Physical Structure chart is known as the hardware root (HW_Root). Every Galaxy system has a single hardware root. It is useful to think of this as the physical floorplan of the machine. If a physical device has no specific lower place in the component hierarchy, it appears as a child of the hardware root. A component that is a child can be assigned to other devices in the hierarchy when the machine is partitioned or logically defined.

NOTE Clicking the root instance of any chart performs an auto-layout operation if the Auto Layout mode is set.

Ownership Overlay

Choose Ownership Overlay from the Windows menu to display the initial owner relationships for the various components. These relationships indicate the instance that owns the component after a power cycle. Once a system has been booted, migratable components may change owners dynamically. To alter the initial ownership, the console environment variables must be changed.

The ownership overlay has no effect on the Physical Structure chart or the Failover Target chart.

Logical Structure Chart

The Logical Structure chart displays Galaxy communities and instances and is the best illustration of the relationships that form the Galaxy. Below these components are the various devices they currently own. Ownership is an important distinction between the Logical Structure chart and Physical Structure chart. In a Galaxy, resources that can be partitioned or dynamically reconfigured have two distinct owners.

The owner describes where the device turns up after a system power-up. This value is determined by the console firmware during bus-probing procedures and through interpretation of the Galaxy environment variables. The owner values are stored in console nonvolatile memory so that they can be restored after a power cycle.

The CURRENT_OWNER describes the owner of a device at a particular moment in time. For example, a CPU is free to reassign among instances. As it does, its CURRENT_OWNER value is modified, but its owner value remains whatever it was set to by the LP_CPU_MASK# environment variables.

The Logical Structure chart illustrates the CURRENT_OWNER relationships. To view the nonvolatile owner relationships, select Ownership Overlay from the Window menu.

The following sections describe the components of the Logical Structure chart.

Software Root

The topmost component in the Logical Structure chart is known as the software root (SW_Root). Every Galaxy system has a single software root. If a physical device has no specific owner, it appears as a child of the software root. A component that has a child can be assigned to other devices in the hierarchy when the machine is logically defined.

NOTE Clicking the root instance of any chart performs an auto-layout operation if the Auto Layout mode is set.

Unassigned Resources

You can configure Galaxy partitions without assigning all devices to a partition, or you can define but not initialize one or more partitions. In either case, some hardware may be unassigned when the system boots.

The console firmware handles unassigned resources in the following manner:

- Unassigned CPUs are assigned to partition 0.
- Unassigned memory is ignored.

Devices that remain unassigned after the system boots appear to be assigned to the software root component and may not be accessible.

Community Resources

Resources such as shared memory can be accessed by all instances within a sharing community. Therefore, for shared memory, the community itself is considered the owner.

Instance Resources

Resources that are currently or permanently owned by a specific instance are displayed as children of the instance component.

Memory Assignment Chart

The Memory Assignment chart illustrates the partitioning and assignment of memory fragments among the Galaxy instances. This chart displays both hardware components (arrays, controllers, and so on) and software components (memory fragments).

Current Galaxy firmware and operating system software does not support dynamic reconfiguration of memory. Therefore, the Memory Assignment chart reflects the way the memory address space has been partitioned by the console among the Galaxy instances. This information can be useful for debugging system applications or for studying possible configuration changes.

The following sections discuss memory fragments.

Console Fragments

The console requires one or more small fragments of memory. Typically, a console allocates approximately 2 MB of memory in the low address range of each partition. This varies by hardware platform and firmware revision. Additionally, some consoles allocate a small fragment in high address space for each partition to store memory bitmaps. The console firmware may need to create additional fragments to enforce proper memory alignment.

Private Fragments

Each Galaxy instance is required to have at least 64 MB of private memory (including the console fragments) to boot OpenVMS. This memory can consist of a single fragment, or the console firmware may need to create additional private fragments to enforce proper memory alignment.

Shared Memory Fragments

To create an OpenVMS Galaxy, a minimum of 8 MB of shared memory must be allocated. This means the minimum memory requirement for an OpenVMS Galaxy is actually 72 MB (64 MB for a single instance and 8 MB for shared memory).

CPU Assignment Chart

The CPU Assignment chart displays the minimal number of components required to reassign CPUs among the Galaxy instances. This chart can be useful for working with very large Galaxy configurations.

Primary CPU

Each primary CPU is displayed as an oval rather than a hexagon. This is a reminder that primary CPUs cannot be reassigned or stopped. If you attempt to drag and drop a primary CPU, the GCU displays an error message in its status bar and does not allow the operation to occur.

Secondary CPUs

Secondary CPUs are displayed as hexagons. Secondary CPUs can be reassigned among instances in either the Logical Structure chart or the CPU Assignment chart. Drag and drop the CPU on the desired instance. If you drop a CPU on the same instance that currently owns it, the CPU stops and restarts.

Fast Path and Affinitized CPUs

If you reassign a CPU that has a Fast Path device currently affinitized to the CPU, the affinity device moves to another CPU and the CPU reassignment succeeds. If a CPU has a current process affinity assignment, the CPU cannot be reassigned.

For more information about using OpenVMS Fast Path features, see the *HP OpenVMS I/O User's Reference Manual*.

Lost CPUs

You can reassign secondary CPUs to instances that are not yet booted (partitions).

Similarly, you can reassign a CPU to an instance that is not configured as a member of the Galaxy sharing community. In this case, you can push the CPU away from its current owner instance, but you cannot get it back unless you log in to the independent instance (a separate security domain) and reassign the CPU back to the current owner.

Regardless of whether an instance is part of the Galaxy sharing community or is an independent instance, it is still present in the Galaxy configuration file; therefore, the GCU is still able to display it.

IOP Assignment Chart

The IOP Assignment chart displays the current relationship between I/O modules and the Galaxy instances. Note that, depending on what type of hardware platform is being used, a single-instance Galaxy on any Alpha system may not show any I/O modules in this display.

Failover Target Chart

The Failover Target chart shows how each processor automatically fails over to other instances in the event of a shutdown or failure. Additionally, this chart illustrates the state of each CPU's autostart flag.

For each instance, a set of failover objects are shown, representing the full set of potential CPUs. By default, no failover relationships are established and all autostart flags are set.

To establish automatic failover of specific CPUs, drag and drop the desired failover object to the instance you want the associated CPU to target. To set failover relationships for all CPUs owned by an instance, drag and drop the instance object on top of the instance you want the CPUs to target.

To clear individual failover targets, drag and drop a failover object back to its owner instance. To clear all failover relationships, right-click on the instance object to display the Parameters &Commands dialog box, click on the Commands button, click the "Clear ALL failover targets?", button and then click OK.

By default, whenever a failover operation occurs, the CPUs automatically start once they arrive in the target instance. You can control this autostart function using the autostart commands found in the Parameters & Commands dialog box for each failover object, or each instance object. The Failover Target chart displays the state of the autostart flag by displaying the failover objects in green if autostart is set, and red if autostart is clear.

Please note the following restrictions in the current implementation of failover and autostart management:

- The failover and autostart settings are not preserved across system boots. Therefore, you need to reestablish the model whenever the system reboots. To do this, invoke a previously saved configuration model, either by manually restoring the desired model or by using a command procedure during system startup.
- The GCU currently is not capable of determining the autostart and failover relationships of instances other than the one the GCU is running on, unless the instances are clustered.
- The GCU currently does not respond to changes in failover or autostart state that are made from another executing copy of the GCU or from DCL commands. If this state is altered, the GCU refreshes its display only if the active model is closed and then reopened.

Viewing Component Parameters

Each component has a set of parameters that can be displayed and, in some cases, altered. To display a component's parameters, position the cursor on the desired component, click the right mouse button, and select the Parameters item from the pop-up menu entry. Alternately, you can select a component and then select the Parameters item from the Components menu.

Where parameters are subject to unit conversion, changing the display unit updates the display and any currently visible parameter dialog boxes. Other parameters represent a snapshot of the system component and are not dynamically updated. If these parameters change, you must close and then reopen the Parameters dialog box to see the updated values.

Executing Component Commands

A component's Parameters dialog box can also contain a command page. If so, you can access the commands by clicking on the Commands button at the top of the dialog box. Most of the commands are executed by clicking on their toggle buttons and then clicking the OK or Apply buttons. Other commands may require that you enter information, or select values from a list or option menu. Note that if you select several commands, they are executed in a top-down order. Be sure to choose command sequences that are logical.

Customizing GCU Menus

System managers can extend and customize the GCU menus and menu entries by creating a file named SYS$MANAGER:GCU$CUSTOM.GCR. The file must contain only menu statements formatted as shown in the following examples. The GCU$CUSTOM.GCR file is optional. It is preserved during operating system upgrades.

```
FORMAT EXAMPLE:

MENU "Menu-Name" "Entry-Name" Procedure-type "DCL-command"
    * Menu-Name - A quoted string representing the name of the
                  pulldown menu to add or extend.
```

```
* Entry-Name - A quoted string representing the name of the
               menu entry to add.

* Procedure-type - A keyword describing the type of procedure
               to invoke when the menu entry is selected.

  Valid Procedure-type keywords include:

  COMMAND_PROCEDURE - Executes a DCL command or command file.
  SUBPROC_PROCEDURE - Executes a DCL command in subprocess context.

* DCL-command - A quoted string containing a DCL command statement
               consisting of an individual command or invokation
               of a command procedure.
```

To create a procedure to run on other instances, write a command procedure that uses SYSMAN or task-to-task methods similar to what the GCU uses in SYS$MANAGER:GCU$ACTIONS.COM. You can extend GCU$ACTIONS.COM, but this file is replaced during operating system upgrades and is subject to change.

EXAMPLE MENU STATEMENTS (place in SYS$MANAGER:GCU$CUSTOM.GCR):

```
// GCU$CUSTOM.GCR - GCU menu customizations
// Note that the file must end with the END-OF-FILE statement.
//
MENU "Tools" "Availability Manager" SUBPROC_PROCEDURE "AVAIL/GROUP=DECamds"
MENU "Tools" "Create DECterm" COMMAND_PROCEDURE  "CREATE/TERM/DETACH"
MENU "DCL"   "Show CPU"       COMMAND_PROCEDURE  "SHOW CPU"
MENU "DCL"   "Show Memory"    COMMAND_PROCEDURE  "SHOW MEMORY"
MENU "DCL"   "Show System"    COMMAND_PROCEDURE  "SHOW SYSTEM"
MENU "DCL"   "Show Cluster"   COMMAND_PROCEDURE  "SHOW CLUSTER"
END-OF-FILE
```

Monitoring an OpenVMS Galaxy with HP Availability Manager

The Availability Manager software provides a valuable real-time view of the Galaxy system. Availability Manager can monitor all Galaxy instances from a single workstation or PC anywhere on the local area network. Availability Manager utilizes a custom OpenVMS driver (RMDRIVER) that periodically gathers availability data from the system. This information is returned to the Availability Manager Data Analyzer using a low-level Ethernet protocol.

The Data Analyzer provides numerous views and graphs of the system's availability characteristics. Additionally, when Availability Manager detects one of numerous known conditions, it notifies the user and offers a set of solutions (called fixes) that can be applied to resolve the condition.

Every OpenVMS system comes with the Availability Manager Data Collector (RMDRIVER) installed. To enable the collector, you must execute its startup procedure inside SYSTARTUP_VMS.COM or manually on each Galaxy instance you want to monitor. Enter the following commands to start or stop the data collector:

```
$ @SYS$STARTUP:AMDS$STARTUP START
```

or:

```
$ @SYS$STARTUP:AMDS$STARTUP STOP
```

Before starting the collector, you need to specify a group name for your Galaxy. Do so by editing the SYS$MANAGER:AMDS$LOGICALS.COM file. This file includes a statement for declaring a group name. Choose any unique name, making sure this file on each Galaxy instance contains the same group name.

When using Availability Manager, OpenVMS Engineering finds it useful to display the System Overview window and a CPU Modes Summary Page of the Node Summary Page for each Galaxy instance. There are a number of additional views you can monitor depending on your specific interests. For more information about Availability Manager, see the *HP OpenVMS Availibility Manager User's Manual*.

Running the CPU Load Balancer Program

The OpenVMS Galaxy CPU Load Balancer program is a privileged application that dynamically reassigns CPU resources among instances in an OpenVMS Galaxy.

For information about how to run this program from the GCU, see Appendix A.

Creating an Instance

The current implementation of the Galaxy Software Architecture for OpenVMS requires that you predefine the Galaxy instances you intend to use. You can do this by using console environment variables. See the appropriate sections of this guide for more details about Galaxy environment variables.

Dissolving an Instance

The only way to effectively dissolve a Galaxy instance is to shut it down, reassign its resources using console environment variables or procedures, and, if necessary, reboot any instances that acquire new resources.

Shutdown and Reboot Cycles

Resources such as CPUs can be dynamically reassigned once the involved instances are booted. To reassign statically assigned resources, such as I/O modules, you must shut down and reboot the involved instances after executing the appropriate console commands.

Online Versus Offline Models

The GCU allows you to display and interact with the active (online) or inactive (offline) Galaxy configuration models. When the configuration display represents a model of the active system, the GCU displays the state of the CPUs and instances using color and text. When the configuration model is engaged in this manner, you can interact with the active system using drag-and-drop procedures. The formal description for this mode of operation is interacting with the engaged, online model.

GCU users can also interact with any number of disengaged, or offline, models. Offline models can be saved to or loaded from files. An offline model can also be derived from the active online model by clicking the Engage button to be disengaged when the active online model is displayed. In addition to the visual state of the Engage button, the GCU also indicates the online versus offline characteristic of the CPUs and instances by using color and text. Any drag-and-drop actions directed at an offline model are interpreted as simple editing functions. They change the internal structure of the model but do not affect the active system.

When an offline model is engaged, the GCU compares the structure of the model with that of the active system. If they agree, the offline model is engaged and its new online state is indicated with color and text. If they do not agree, the GCU determines what management actions would be required to alter the active system to match the proposed model. A list of the resulting management actions is presented to the user, and the user is asked whether they would like to execute the action list. If the user disapproves, the model remains off line and disengaged. If the user approves, the GCU executes the management actions and the resulting model is displayed as on line and engaged.

GCU System Messages

The following system messages are displayed by the GCU when an error occurs.

```
%GCU-E-SUBPROCHALT, Subprocess halted; See GCU.LOG.

  The GCU has launched a user-defined subprocess which has terminated
  with error status.  Details may be found in the file GCU.LOG.

%GCU-S-SUBPROCTERM, Subprocess terminated

  The GCU has launched a user-defined subprocess which has terminated.

%GCU-I-SYNCMODE, XSynchronize activated

  The GCU has been invoked with X-windows synchronous mode enabled.
  This is a development mode which is not generally used.

%GCU-W-NOCPU, Unable to locate CPU

  A migration action was initiated which involved an unknown CPU.  This
  can result from engaging a model which contains invalid CPU identifiers
  for the current system.

%GCU-E-NORULESET, Ruleset not found:

  The GCU was unable to locate the Galaxy Configuration Ruleset in
  SYS$MANAGER:GALAXY.GCR.  New versions of this file can be downloaded
  from the OpenVMS Galaxy web page.
```

```
%GCU-E-NOMODEL, Galaxy configuration model not found:

  The specified Galaxy Configuration Model was not found.  Check your
  command line model file specification.

%GCU-W-XTOOLKIT, X-Toolkit Warning:

  The GCU has intercepted an X-Toolkit warning.  You may or may not be
  able to continue, depending on the type of warning.

%GCU-S-ENGAGED, New Galaxy configuration model engaged

  The GCU has successfully engaged a new Galaxy Configuration Model.

%GCU-E-DISENGAGED, Unable to engage Galaxy configuration model

  The GCU has failed to engage a new Galaxy Configuration Model.  This
  can happen when a specified model is invalid for the current system, or
  when other system activities prevent the requested resource assignments.

%GCU-E-NODECW, DECwindows is not installed.

  The current system does not have the required DECwindows support.

%GCU-E-HELPERROR Help subsystem error.

  The DECwindows Help system (Bookreader) encountered an error.

%GCU-E-TOPICERROR Help topic not found.

  The DECwindows Help system could not locate the specified topic.

%GCU-E-INDEXERROR Help index not found.

  The DECwindows Help system could not locate the specified index.

%GCU-E-UNKNOWN_COMPONENT: {name}

  The current model contains reference to an unknown component.  This
  can result from model or ruleset corruption.  Search for the named
  component in the ruleset SYS$MANAGER:GALAXY.GCR.  If it is not found,
  download a new one from the OpenVMS Galaxy web site.  If the problem
  persists, delete and recreate the offending model.

%GCU-I-UNASSIGNED_HW: Found unassigned {component}"

  The GCU has detected a hardware component which is not currently
  assigned to any Galaxy instance.  This may result from intentionally
  leaving unassigned resources.  Note the message and continue or
  assign the hardware component from the primary Galaxy console and
  reboot.

%GCU-E-UNKNOWN_KEYWORD: {word}

  The GCU has parsed an unknown keyword in the current model file.  This
  can only result from model file format corruption.  Delete and
  recreate the offending model.

%GCU-E-NOPARAM: Display field {field name}

  The GCU has parsed an incomplete component statement in the current
  model.  This can only result from model file format corruption.
  Delete and recreate the offending model.
```

```
%GCU-E-NOEDITFIELD: No editable field in display.

  The GCU has attempted to edit a component parameter which is undefined.
  This can only result from model file format corruption.  Delete and
  recreate the offending model.

%GCU-E-UNDEFTYPE, Undefined Parameter Data Type: {type}

  The GCU has parsed an unknown data type in a model component parameter.
  This can result from model file format corruption or incompatible
  ruleset for the current model.  Search the ruleset SYS$MANAGER:GALAXY.GCR
  for the offending datatype.  If not found, download a more recent
  ruleset from the OpenVMS Galaxy web site.  If found, delete and
  recreate the offending model.

%GCU-E-INVALIDMODEL, Invalid model structure in: {model file}

  The GCU attempted to load an invalid model file.  Delete and recreate
  the offending model.

%GCU-F-TERMINATE Unexpected termination.

  The GCU encountered a fatal DECwindows event.

%GCU-E-GCTLOOP: Configuration Tree Parser Loop

  The GCU has attempted to parse a corrupt configuration tree.  This
  may be a result of console firmware or operating system fault.

%GCU-E-INVALIDNODE: Invalid node in Configuration Tree

  The GCU has parsed an invalid structure within the configuration tree.
  This can only result from configuration tree corruption or revision
  mismatch between the ruleset and console firmware.

%GCU-W-UNKNOWNBUS: Unknown BUS subtype: {type}

  The GCU has parsed an unknown bus type in the current configuration
  tree.  This can only result from revision mismatch between the
  ruleset and console firmware.

%GCU-W-UNKNOWNCTRL, Unknown Controller type: {type}

  The GCU has parsed an unknown controller type in the current configuration
  tree.  This can only result from revision mismatch between the
  ruleset and console firmware.

%GCU-W-UNKNOWNCOMP, Unknown component type: {type}

  The GCU has parsed an unknown component type in the current configuration
  tree.  This can only result from revision mismatch between the
  ruleset and console firmware.

%GCU-E-NOIFUNCTION, Unknown internal function

  The user has modified the ruleset file and specified an unknown
  internal GCU function.  Correct the ruleset or download a new one
  from the OpenVMS Galaxy web page.

%GCU-E-NOEFUNCTION, Missing external function

  The user has modified the ruleset file and specified an unknown
  external function.  Correct the ruleset or download a new one
  from the OpenVMS Galaxy web page.
```

```
%GCU-E-NOCFUNCTION, Missing command function

  The user has modified the ruleset file and specified an unknown
  command procedure.  Correct the ruleset or download a new one
  from the OpenVMS Galaxy web page.

%GCU-E-UNKNOWN_COMPONENT: {component}

  The GCU has parsed an unknown component.  This can result from
  ruleset corruption or revision mismatch between the ruleset and
  console firmware.

%GCU-E-BADPROP, Invalid ruleset DEVICE property

  The GCU has parsed an invalid ruleset component statement.  This can
  only result from ruleset corruption.  Download a new one from the
  OpenVMS Galaxy web page.

%GCU-E-BADPROP, Invalid ruleset CHART property

  The GCU has parsed an invalid chart statement.  This can
  only result from ruleset corruption.  Download a new one from the
  OpenVMS Galaxy web page.

%GCU-E-BADPROP, Invalid ruleset INTERCONNECT property

  The GCU has parsed an invalid ruleset interconnect statement.  This can
  only result from ruleset corruption.  Download a new one from the
  OpenVMS Galaxy web page.

%GCU-E-INTERNAL Slot {slot detail}

  The GCU has encountered an invalid datatype from a component parameter.
  This can result from ruleset or model corruption.  Download a new one
  from the OpenVMS Galaxy web page.  If the problem persists, delete and
  recreate the offending model.

%GCU-F-PARSERR, {detail}

  The GCU encountered a fatal error while parsing the ruleset.  Download
  a new one from the OpenVMS Galaxy web page.

%GCU-W-NOLOADFONT: Unable to load font: {font}

  The GCU could not locate the specified font on the current system.
  A default font will be used instead.

%GCU-W-NOCOLORCELL: Unable to allocate color

  The GCU is unable to access a colormap entry.  This can result from
  a system with limited color support or from having an excessive number
  of graphical applications open at the same time.

 GCU-E-NOGALAXY, This system is not configured as a Galaxy.

  Description:

     The user has issued the CONFIGURE GALAXY/ENGAGE command on a
     system which is not configured for Galaxy operation.

  User Action:

     Configure your system for Galaxy operation using the procedures
```

```
     described in the OpenVMS Galaxy Guide.  If you only want to run a
     single-instance Galaxy, enter CONFIGURE GALAXY without the
     /ENGAGE qualifier and follow the instructions provided by the
     Galaxy Configuration Utility.

%GCU-E-ACTIONNOTALPHA GCU actions require OpenVMS Alpha

  A GCU user has attempted to invoke a Galaxy configuration operation
  on an OpenVMS VAX system.

%GCU-I-ACTIONBEGIN at {time}, on {instance} {mode}

  This informational message indicates the start of a configuration
  action on the specified Galaxy instance.  Note that many actions
  require collaboration between command environments on two separate
  Galaxy instances, thus, you may encounter two of these messages, one
  per instance involved in the operation.  The mode argument indicates
  which instance is local versus remote.

%GCU-S-ACTIONEND  at {time}, on {nodename}

  This is the normal successful completion message following a Galaxy
  configuration action.  Note that many actions require collaboration
  between command environments on two separate Galaxy instances, thus, you
  may encounter two of these messages, one per instance involved in the
  operation.

%GCU-S-ACTIONEND, Exiting GCU$ACTIONS on ^Y

  Indicates that the user has aborted a Galaxy configuration action
  using Control-Y.

%GCU-S-ACTIONEND, Exiting GCU$ACTIONS on error {message}

  Indicates that a Galaxy configuration action terminated with error
  status as indicated by the message argument.

%GCU-E-ACTIONUNKNOWN no action specified

  Indicates that the GCU$ACTIONS.COM procedure was called improperly.
  It is possible that the command procedure has been corrupted or is
  out of revision for the current system.

%GCU-E-ACTIONNOSIN no source instance name specified

  Indicates that the GCU$ACTIONS.COM procedure was called improperly.
  It is possible that the command procedure has been corrupted or is
  out of revision for the current system.

%GCU-E-ACTIONBAD failed to execute the specfied action

  Indicates that a Galaxy configuration action aborted due to an
  indeterminate error condition.  Review related screen messages and
  verify that the necessary proxy accounts have been established.

%GCU-E-INSFPRIVS, Insufficient privileges for attempted operation

  An underprivileged user has attempted to perform a Galaxy configuration
  action.  Typically, these actions are performed from within the system
  managers account.  OPER and SYSPRV privileges are required.

%GCU-E-NCF network connect to {instance} failed

  An error has occurred trying to open a DECnet task-to-task connection
```

```
between the current and specified instances.  Review related screen
messages and verify that the necessary proxy accounts have been
established.
```

14 The Graphical Configuration Manager

This chapter describes the HP Graphical Configuration Manager (GCM) for OpenVMS that is included in the network kit. This chapter describes how to install the GCM server and the GCM client from the kit, and contains basic instructions for establishing a GCM client/server session. Once you have performed the basic GCM setup, you can get more information about GCM from the GCM client Help menu.

Overview

The HP Graphical Configuration Manager (GCM) for OpenVMS is a portable, client/server application that provides a visual means of viewing and controlling the configuration of partitioned AlphaServer systems running OpenVMS. The GCM client is a Java-based application that can run on any operating system that supports the Java™ run-time environment (JDK V1.2.2 or higher) and a TCP/IP network. A GCM server runs as a detached process on each partitioned OpenVMS instance on one or more AlphaServer systems. You use GCM to configure and manage Galaxy systems in much the same way that you use GCU: the difference is that GCU is a DECwindows Motif application and GCM is a Java-based one.

NOTE The GCM client is not supported on Java JDK Version 1.3 or greater at this time.

All network communication performed by the HP OpenVMS Graphical Configuration Manager uses Secure Sockets Layer (SSL). The GCM administration database is encrypted.

From a GCM client, an OpenVMS system manager can establish a secure connection to one or more GCM servers, and perform the following functions:

- Display the configuration of partitioned AlphaServers.
- Utilize hotswap characteristics of the current hardware platform.
- Execute distributed commands among partitioned instances.
- Reassign resources among soft-partitioned instances.
- View resource-specific characteristics.
- Shut down or reboot one or more instances.
- Invoke additional management tools.
- Create and engage Galaxy configuration models.
- View online documentation.

An **association** is a group of OpenVMS instances, each of which has the GCM server installed and shares a common GCM administration database. By defining associations, system managers can use a wide range of deployment strategies to meet their operational needs. For example, you can create hard partitions on a large system to serve different corporate departments or divisions. Within these hard partitions, you can create soft partitions to further segregate individual work groups or user groups. A complex environment such as this may have many separate system managers, each responsible for a different set of hard and soft partitions. In

addition, you can define an overall management function with responsibility for either all or a subset of the partitions. GCM allows you to define specific associations and authorize specific access privileges to individual users.

In the most simple deployment, a single GCM server runs on the single soft partition of a single hard partition. Association records in the administration database identify the hard partition (and its soft partition) as a unique entity that is to be managed as an individual system.

In the most complex deployment, a GCM server runs on each soft partition within each hard partition of many different systems (GS series, ES40, 4100, 8*xxx*). Association records in the administration database identify the group of systems that form the combined entity to be managed. When an association consists of multiple systems and partitions, each GCM server identifies itself to every other GCM server in the association, thereby establishing a secure communications grid that allows you to perform advanced distributed management functions.

Installation Prerequisites

This section lists the software and hardware requirements for installing and running GCM.

Software Requirements

GCM server:

- OpenVMS Alpha Version 7.2–1H1 or greater
- HP TCP/IP Services for OpenVMS (shipped with HP OpenVMS)

GCM client:

- For OpenVMS
  - — OpenVMS Version 7.2 or higher
  - — HP TCP/IP Services for OpenVMS (shipped with HP OpenVMS)
  - — Java (JDK Version 1.2.2) Run-Time Environment (installed when you install the client)
- For the PC
  - — Windows NT® or Windows® 2000
  - — TCP/IP Services for OpenVMS
  - — Java (JDK Version 1.2.2 or higher) Run-Time Environment

NOTE The GCM client is not supported on Java JDK Version 1.3 or greater at this time.

Hardware Requirements

The performance of GCM is affected by the size and configuration of the association. A larger, more complex association (one that contains many GCM servers) results in slower network transfers.

Each machine running a GCM client should have a display of at least 800x600 pixels (SVGA).

Each PC running a GCM client should contain at least 128 MB memory.

Installation Procedure

This section describes how to install the components of the GCM. Installation consists of the following steps:

- Installing one GCM server (see "Installing the GCM Server" on page 139).
- Installing one GCM client (see "Installing the GCM Client" on page 141).
- Performing GCM server setup tasks to establish a basic configuration, including authorizing initial user with administrator privilege (see "Setting Up the GCM Server" on page 142).
- Running the GCM client (with administrator privilege) to finish configuring the association (see "Setting Up the GCM Server" on page 142).
- Propagating the GCM administration database (see "Setting Up the GCM Server" on page 142).
- Authorizing additional users (see "Setting Up the GCM Server" on page 142).

Kits

You can always find the latest versions of the POLYCENTER Software Installation utility kits for the OpenVMS GCM server and client on the OpenVMS web site, which is located at:

`http://www.openvms.hp.com`

Click on "Products" to find the location of downloadable kits for the OpenVMS client and server, and the zip file for the Windows client.

GCM is also available on the OpenVMS Alpha Version 7.3–2 Layered Product CD-ROM, which is shipped along with the operating system.

Installing the GCM Server

The GCM server is preinstalled on OpenVMS Version 7.3–1 and higher versions. On previous versions of OpenVMS (Version 7.2–1H1 or higher), you can install the GCM server with the POLYCENTER Software Installation utility kit (see Kits).

Installing the GCM server does the following:

- Installs (or updates) the SYS$COMMON:[SYSEXE]GCM_SERVER.EXE image.
- Installs the SYS$COMMON:[SYS$STARTUP]GCMSRV$STARTUP.COM file.
- Defines the SYS$COMMON:[SYS$CONFIG] directory with the logical name GCMSRV$DIR.
- Installs the following files in directory GCMSRV$DIR:
  - GCM_RULESET.XML
  - GCM_CUSTOM.XML
  - GCM_BANNER.JPG
  - GCM_NOTICE.HTML
  - GCM$SETUP.EXE

— GCM_CERT.PEM

— GCM_PRIVKEY.PEM

Example 14-1 shows a sample GCM server installation.

Example 14-1 Sample GCM Server Installation

```
$ PRODUCT INSTALL GCM_SERVER

The following product has been selected:
  CPQ AXPVMS GCM_SERVER V1.0              Layered Product

Do you want to continue?  [YES]

Configuration phase starting . . .

You will be asked to choose options, if any, for each selected product
and for any selected products that may be installed to satisfy software
dependency requirements.

CPQ AXPVMS GCM_SERVER V1.0:  Graphical Configuration Manager V1.0

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     Compaq Computer Corporation

     License and Product Authorization Key (PAK) Information

* This product does not have any configuration options.

     Copying GCM Release Notes to SYS$HELP

     Will install the GCM Server V1.0.

     GCM Startup File

Execution phase starting . . .

The following product will be installed to destination:
    CPQ AXPVMS GCM_SERVER V1.0        DISK$WFGLX5_X931:[VMS$COMMON.]

Portion done:  0%...10%...20%...30%...90%...100%

The following product has been installed:
    CPQ AXPVMS GCM_SERVER V1.0        Layered Product
$
```

Example 14-2 lists the files in the current directory after the GCM server is installed.

Example 14-2 Directory of GCM Server Files

```
$ SET DEFAULT SYS$COMMON:[SYS$CONFIG]
$ DIRECTORY

Directory SYS$COMMON:[SYS$CONFIG]

GCM$SETUP.EXE;1   GCM_BANNER.JPG;1   GCM_CERT.PEM;1    GCM_CUSTOM.XML;1
GCM_NOTICE.HTML;1 GCM_PRIVKEY.PEM;1  GCM_RULESET.XML;1 GCM_SERVER.COM;1
```

Installing the GCM Client

OpenVMS GCM Client describes how to install the OpenVMS GCM client. PC GCM Client describes how to install the PC GCM client.

OpenVMS GCM Client

Example 14-3 shows a sample OpenVMS GCM client installation.

Example 14-3 OpenVMS GCM Client Installation

```
$ PRODUCT INSTALL GCM_CLIENT

The following product has been selected:
  CPQ AXPVMS GCM_CLIENT V1.0              Layered Product

Do you want to continue?  [YES]

Configuration phase starting . . .

You will be asked to choose options, if any, for each selected product
and for any selected products that may be installed to satisfy software
dependency requirements.

CPQ AXPVMS GCM_CLIENT V1.0:  Graphical Configuration Manager V1.0 Client

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     Compaq Computer Corporation

     License and Product Authorization Key (PAK) Information

* This product does not have any configuration options.

     Copying GCM Release Notes to SYS$HELP

     Will install the GCM Java Client V1.0.

     Will install a private copy of the Java JRE V1.2.2-3.

     Will install a private copy of the Java Fast VM V1.2.2-1

Execution phase starting . . .

The following product will be installed to destination:
    CPQ AXPVMS GCM_CLIENT V1.0        DISK$WFGLX5_X931:[VMS$COMMON.]

Portion done:  0%...10%...20%...30%...90%...100%

The following product has been installed:
    CPQ AXPVMS GCM_CLIENT V1.0        Layered Product
$
```

Example 14-4 lists the files in the current directory the OpenVMS GCM client is installed in. Note that the OpenVMS GCM client installation installs the Java Run-Time Environment in the JRE.DIR directory.

Example 14-4 Directory of GCM Client Files

```
$ SET DEFAULT SYS$COMMON:[GCM_CLIENT]
$ DIRECTORY
```

```
Directory SYS$COMMON:[GCM_CLIENT]

BIN.DIR;1  GCM_CERT.CRT;1  IMAGES.DIR         JRE122.DIR;1
LIB.DIR;1  README.TXT;1;1  RUN_GCMCLIENT.COM;1
```

PC GCM Client

To install the PC GCM client, first copy the GCM Client zip file, which can be found on the OpenVMS Software web site at

```
http://www.openvms.hp.com/openvms
```

and then use a zip utility to install the GCM client.

You can also find GCM on the OpenVMS Alpha Version 7.3–2 Layered Product CD-ROM.

The installation process allows you to select the Windows directory that will contain the GCM client. Note that to retain any preferences between GCM client sessions, you must start the GCM client from the directory you select during installation. You can accomplish this by clicking the GCM Client icon.

Setting Up the GCM Server

To set up the GCM server, first set default to the SYS$COMMON:[SYS$CONFIG] directory, and then run GCM$SETUP.EXE to perform the following tasks:

- Define the initial configuration of the association.
- Authorize the initial user (username, password, and privileges).
- Choose whether or not to start the GCM server immediately.
- Determine whether or not to automatically start the GCM server when the system boots.

During GCM server setup, you can also choose to authorize additional GCM users.

Running GCM$SETUP.EXE generates and encrypts the GCM administration database file SYS$COMMON:[SYS$CONFIG]GCM_ADMIN.EDB. Choosing to start the GCM server executes the SYS$STARTUP:GCMSRV$STARTUP.COM procedure, which results in the following:

- Creation and execution of GCMSRV$DIR:GCM_STARTUP.COM, which starts the GCM server as a detached process with the log file GCMSRV$DIR:GCM_SERVER.LOG.
- Starting the GCM server with process name GCM_SERVER.

NOTE The GCM server automatically restarts after a server fault. If the GCM server hangs, it will time out and restart. You can also enter a RESTART command from a suitably privileged GCM client.

The first time a GCM server restarts, its process name is GCM_SERVER01. Thereafter, each time the GCM server restarts, its process name is incremented by one, up to GCM_SERVER99; at that point, subsequent restarts are disabled to prevent the GCM server from entering a restart loop.

You can prevent attempts at automatic restart by defining the system logical name GCMSRV$ABORT. After you eliminate the cause of the restart attempts, you must deassign this logical name to enable automatic restart of the GCM server.

Example 14-5 is an example of how to set up the initial GCM server configuration.

Example 14-5 Sample GCM Server Setup

```
$ SET DEFAULT SYS$CONFIG
$ DIRECTORY

Directory SYS$COMMON:[SYS$CONFIG]

GCM$SETUP.EXE;1     GCM_BANNER.JPG;1    GCM_CERT.PEM;1      GCM_CUSTOM.XML;1
GCM_NOTICE.HTML;1   GCM_PRIVKEY.PEM;1   GCM_RULESET.XML;1

Total of 7 files.
$ RUN GCM$SETUP

OpenVMS GCM-Server Setup Utility
Copyright 2002, Hewlett Packard Corporation

This utility initializes the GCM Administrative Database:
SYS$COMMON:[SYS$CONFIG]GCM_ADMIN.EDB

If you are performing an initial GCM-Server installation that will
create an Association of more than a single server instance, you must
perform the following tasks to assure proper server synchronization:

1) Create the new local database using this utility.
2) Copy the database to all other GCM-Server instances in your
   Association.
3) Start each GCM-Server.

You can start servers via $@SYS$STARTUP:GCMSRV$STARTUP.COM or by
invoking this utility on each system.  When an existing database is
found, this utility will offer additional server startup options.

Continue (Y/N) {Y}?

Do you prefer full text assistance (Y/N) {N}? y

SERVER DISCOVERY TCP/IP PORT NUMBER:

Use the default Port Number 4100 (Y/N) {Y}? y

CONNECTION BOUNDS:

Use the default concurrent CLIENT limit of 4 (Y/N) {Y}? y

Use the default concurrent SERVER limit of 8 (Y/N) {Y}? y

CONNECTION SECURITY:

WARNING - DISABLING SECURITY COULD POTENTIALLY COMPROMISE THE
INTEGRITY OF YOUR SYSTEM AND IS NOT RECOMMENDED BY HEWLETT PACKARD.

Use SSL Client-Server Security (Y/N) {Y}? y

%SECURITY - WILL BE ENABLED.

SERVER ASSOCIATION RECORD:

Enter the Association Name (use no quotes): GCM Test Association

SYSTEM RECORDS:

Enter a SYSTEM Name (ex: star.zko.hp.com) (RETURN when done):
      wfglx4.zko.hp.com
```

```
Enter a System IP Address (0 to use DNS): 16.32.112.16

Enter a System Number (range 0-7): 0

Enter a HARD PARTITION Number (range 0-7): 0

Enter a SOFT PARTITION Number (range 0-7): 0

%Define additional system records as needed...

Enter a SYSTEM Name (ex: star.zko.hp.com) (RETURN when done):
        wfglx5.zko.hp.com

Enter a System IP Address (0 to use DNS): 16.32.112.17

Enter a System Number (range 0-7): 0

Enter a HARD PARTITION Number (range 0-7): 0

Enter a SOFT PARTITION Number (range 0-7): 1

%Define additional system records as needed...

Enter a SYSTEM Name (ex: star.zko.hp.com) (RETURN when done):

CLIENT AUTHORIZATION RECORDS:

Enter Client's Full Name or Title (RETURN when done): First Last

Enter Client's Username: First

Enter initial Password for First: Last

Enter EMAIL Address for First: First.Last@hp.com

Give First CONFIG Privilege (Y/N) {Y}? y

COMMAND privilege allows a user to issue DCL commands.

Give First COMMAND Privilege (Y/N) {Y}? y

Give First USER-COMMAND Privilege (Y/N) {Y}? y

Give First POWER Privilege (Y/N) {Y}? y

Give First ADMIN Privilege (Y/N) {Y}? y

Enable First account now (Y/N) {Y}? y

%Define additional client records as needed...

Enter Client's Full Name or Title (RETURN when done):

SERVER STARTUP OPTIONS:

Do you want the local GCM-SERVER to start on System Boot (Y/N) {Y}? y

Do you want to start the local GCM-SERVER now (Y/N) {Y}? y


********************** POST SETUP TASKS *************************

 This completes the GCM Admin Database initialization.
```

```
IMPORTANT:

If you are using multiple GCM-Servers, copy the newly created GCM
Admin Database file: SYS$COMMON:[SYS$CONFIG]GCM_ADMIN.EDB, to the
same location on each system you defined in the Association, then
start or restart each server via $ @SYS$STARTUP:GCMSRV$STARTUP.COM

If the database has been properly defined, each server will detect
the presence of the other servers and form the specified Association.
If the GCM_SERVER process fails to start, examine the server logfile
SYS$COMMON:[SYS$CONFIG]GCM_SERVER.LOG.

When the server has started, you may use the GCM-Client to establish
a connection and further tune the installation.

For maximum security, you may wish to protect or remove this utility.

$
```

For an example of GCM server setup with complete prompting text that explains each entry, see "Sample Verbose GCM Server Setup" on page 155.

GCM Administration Database

The GCM$SETUP utility prompts you for details regarding system configuration, user identification, and startup methods.

To enhance security, you can rename, delete, or otherwise protect the GCM setup utility after you have run it. The setup utility is required again only if you need to rebuild the initial database.

During the initial setup, you must define at least one system to run the GCM server (typically, the system you are logged in to) and authorize one user with administrator privilege. This user can then run the GCM client and connect to the GCM server for further configuration and tuning. During GCM server setup, you can define additional instances in the association, and you can authorize additional GCM users with individual access privileges. You can also perform these tasks from a GCM client at any time.

The GCM setup utility creates the SYS$COMMON:[SYS$CONFIG]GCM_ADMIN.EDB file, which is the initial GCM administration database. This is an encrypted database that contains information about the association and its users. In normal operation, this database can be interpreted only by the GCM server. (See Troubleshooting the GCM Server.) If you have configured the association with more than one instance, you must manually copy the GCM administration database file to the GCM server directory of each additional instance before you start GCM servers on those instances. Failure to copy the database file can prevent the association from being properly created, or can cause the initial GCM administration database to be overwritten.

Note that changing the configuration of the association, such as by adding a new instance or by removing an instance, is a major modification. Whenever you make a major modification to the association, you must manually copy the GCM administration database file to the GCM server directory on that instance before starting the GCM server.

Minor modifications to the database in an active association automatically propagate to all GCM servers; you do not have to restart the GCM servers. Minor modifications include actions such as adding and removing GCM client records or adjusting GCM server parameters.

Starting the GCM Server

You can start the GCM server automatically (Automatic GCM Server Startup) or manually (Manual GCM Server Startup).

Note that you should run only one GCM server in an instance.

Automatic GCM Server Startup

If you select automatic GCM server startup during server setup (see Setting Up the GCM Server), the setup utility executes the following command:

```
$ MC SYSMAN STARTUP ADD FILE GCMSRV$STARTUP.COM
```

You can also enter this command manually at any time.

The GCMSRV$STARTUP.COM procedure performs the following tasks:

- Defines the required system logical names.
- Creates a small worker procedure, SYS$COMMON:[SYS$CONFIG]GCM_SERVER.COM.
- Runs the GCM server process as a detached process.

To turn off automatic startup, enter the following command:

```
$ MC SYSMAN STARTUP REMOVE FILE GCMSRV$STARTUP.COM
```

Manual GCM Server Startup

You can manually start the GCM server at any time by entering the following command:

```
$ @SYS$STARTUP:GCMSRV$STARTUP
```

Postinstallation Administrative Tasks

The administrator performs the following tasks from a privileged GCM client:

- Authorizes other GCM users (see “Authorizing GCM Users and Defining the Subscription Template” on page 147).
- Posts documents to the library (optional) (see “Managing the Library” on page 148).
- Defines the GCM_BANNER.JPG login banner (optional) (see “Custom Banners” on page 148).
- Posts the system notices GCM_NOTICE.HTML file (optional) (see “System Notices” on page 148).
- Defines custom system and user-level commands (see “Customizing Commands” on page 148).

The following sections and the GCM client help provide more information about these tasks.

Authorizing GCM Users and Defining the Subscription Template

You can define, authorize, and enable GCM users during the GCM server setup procedure, or at any time from the GCM client (with admin privilege). During a a typical installation, you will define the key users of the system from the setup utility. Additional users can request access to the GCM server association using a subscription process and email request.

As part of the postinstallation setup, the first time the GCM server is started it creates SYS$COMMON:[SYS$CONFIG]GCM_TEMPLATE.XML, a subscription template file. This file contains a template to create a subscription form tailored to your specific site. To customize this template, the administrator must connect to a GCM server from a GCM client, and select Edit Subscription Template on the File menu.

When the default subscription template is displayed, complete the form as needed and press OK to return the official template to all active GCM servers. (You can also manually copy this file to the other instances in the configuration if the GCM servers are not yet running.) The subscription form includes fields that allow a potential user to request a user name, password, and access level. As the administrator, you can choose which authorizations to make visible to users. For example, you can disallow users from requesting the Admin privilege if you prefer to keep a single system administrator account.

NOTE GCM user authorization records (user name, password, and so on) are completely independent of any OpenVMS authorization mechanism.

Once the subscription form is initialized, users can discover GCM-capable instances (those running a GCM server) and request a subscription form. A user cannot request a subscription form until the administrator has customized the subscription template. When a user completes the subscription form, it is returned to the GCM server and email is sent to the administrator notifying about a new subscription request. To approve a request, the administrator connects to the association from a GCM client, edits the GCM administration database, and selects options to approve or disapprove of the request. Optionally, the administrator clicks the Email button to bring up an email response to the user advising of the status of the request. As soon as a subscription request is approved and the account is enabled, the updated GCM administration database is automatically propagated to the other GCM servers and the requesting GCM user is allowed access to the GCM servers in the association.

To revoke a GCM user's access privileges, the administrator deletes the client record or simply disables the account. A client that is currently connected is immediately disconnected.

GCM User Privileges

When you authorize a user, you can grant the following privileges:

Privilege	Description
Config	Allows the user to modify the configuration of the association.
Command	Allows the user to define commands for self.
User Command	Allows the user to define commands for all clients.
Admin	Allows the user to edit the GCM administration database (GCM$ADMIN.EDB).
Power	Allows the user to power systems and components on and off.

Managing the Library

The GCM includes a distributed document retrieval system. This system allows you to post documents in directories you specify on individual GCM servers for users to retrieve and view. (To invoke the Library dialog box, select Edit Admin Database on the File menu.) In addition, programs and procedures that run on GCM server systems can produce output files for retrieval and viewing by users.

You can use wildcard characters to search for documents. For example, executing a remote GCM server command procedure may run a performance analysis that generates an Excel spreadsheet output file. Using the GCM, you can invoke this procedure simultaneously on multiple systems in the association. Each system may produce a result file with unique identifying features in its file specification, such as the node name or a timestamp. You can specify the document with wildcards, for example, CFG_*_LOG.CSV. This specification results in a search for matching files on each system. Any matching files are listed in the GCM client's library as documents available for retrieval. Full OpenVMS directory specifications are also allowed.

Whenever a user opens a GCM server library and retrieves a document, a copy of that document is written into the user's GCM client directory. After the user ends GCM client session, these files are still available for viewing in an editor or browser. However, any changes made to the file are not propagated to the library copy on the GCM server. Users must manually delete these outdated files when they no longer need them.

Custom Banners

You can provide a custom banner image for your company or organization by copying your own JPEG file to SYS$COMMON:[SYS$CONFIG]GCM_BANNER.JPG. This file should be a reasonable size to avoid lengthy download delays. This file is displayed in GCM clients as they connect.

System Notices

You can post general system notices for GCM clients by editing the SYS$COMMON:[SYS$CONFIG]GCM_NOTICE.HTML file. This file is a simple hypertext document that can contain messages to display when a GCM client connects to the GCM server. Keep edits to this file simple. You can embed links, but do not embed scripts, images, sounds, and so on. The GCM client's built-in browser (the Java default browser) is less sophisticated than most modern browsers and is not intended for general use.

Customizing Commands

You can customize GCM commands in two ways. A user with user command privilege has access to menu items that allow the user to define and save custom DCL commands. These commands can perform any function supported by OpenVMS and DCL. The GCM server does not currently support interactive commands or command procedures.

NOTE When authorizing the user command privilege, remember that all commands are executed by the GCM server in system context. GCM makes no attempt to prevent you from executing commands that are detrimental to system performance or operation.

You can also create custom commands with extended ruleset definitions. On each GCM server, an option file (SYS$COMMON:[SYS$CONFIG]GCM_CUSTOM.XML) contains simple menu definition statements in XML format. If this file is present when the GCM server starts up, these additional menu commands will appear in the GCM client for all users with the command privilege. This provides a means for system administrators to define instance-specific commands for their users. A sample file is shipped in the kit and contains

instructions for defining additional custom commands. If you do not wish to use this capability, you may delete the custom ruleset file. For more information about using custom commands, see "Defining and Using Commands" on page 151.

Configuring the Association

It is critical to specify the correct values of systems and hard and soft partitions for GCM to run properly. Incorrect values will cause command routing to fail. Before installing the GCM and defining the configuration of the association, it can be helpful to define the association on a worksheet.

Table 14-1 is an example of how to define an association for a system with two hard partitions, each of which contains four soft partitions.[1]

Table 14-1 Sample Worksheet for A Simple Association

Fully Qualified System Name	IP Address	System	Hard Partition	Soft Partition
sysnam1.zko.dec.com	16.32.112.1	0	0	0
sysnam2.zko.dec.com	16.32.112.2	0	0	1
sysnam3.zko.dec.com	16.32.112.3	0	0	2
sysnam4.zko.dec.com	16.32.112.4	0	0	3
sysnam5.zko.dec.com	16.32.112.5	0	1	0
sysnam6.zko.dec.com	16.32.112.6	0	1	1
sysnam7.zko.dec.com	16.32.112.7	0	1	2
sysnam8.zko.dec.com	16.32.112.8	0	1	3

Consideration

An association can be a single system, a combination of hard and soft partitions within a single system, or multiple systems with any combination of hard and soft partitions. Typically, the GCM is used within a single system, including all soft partitions that exist in that system. Although you can extend a GCM association to span multiple systems, including older AlphaServer systems, be aware of the performance impact of creating large associations.

A burst of network traffic is created by the GCM in response to a configuration change. If your association spans many systems and partitions, the volume of data may become excessive. Although HP is continually improving the operation of the GCM, you can define associations that become unmanageable. It is difficult to set limits on association size because of the number of factors that affect performance, such as network speed and load, and GCM client system resources. Note that the design goal for the initial release of the GCM is a maximum of eight partitions. Typical customer installations contain far fewer partitions.

1. A value of zero causes DNS name translation to look up the current IP address.

Adding Systems to An Association

A **system** is a physical machine cabinet. You can add systems to an association with the GCM Setup utility (which requires you to define at least one local system; see Setting Up the GCM Server) or at any time using the GCM client. As you add new systems to the association, you must specify identifying details and, if necessary, adjust GCM server limits.

You must assign a unique system number to each system. For example, a GS320 may have up to eight partitions, all within the same system. System numbers are assigned sequentially starting with zero. Each system number results in the creation of a separate branch of the configuration display.

For each hard partition within each system, you must define a a hard partition number. This must be the actual hard partition number. For example, if you partition a GS320 into four hard partitions, you must be aware of which partitions are numbered zero through three.

For each soft partition within each hard partition, you must define a soft partition number. This must be the actual soft partition number. For example, if you split hard partition number 0 into soft partitions 0 and 1, you must specify the appropriate partition number for each system. Table 14-1 shows a system configured in this way.

Note that all partitions reside within system 0. If you extend your association to include another system with its own set of partitions, those partitions will have system 1 designations.

NOTE It is critical that you set these values correctly. If you fail to provide proper values, GCM will be unable to form the desired association, or will be unable to properly route command traffic through the association. At times you may need to invoke the native Graphical Configuration Utility (GCU) utility with the CONFIGURE GALAXY command to determine the proper identifiers for the GCM.

Note that the GCM server maintains limits over the number of concurrent GCM clients and GCM servers it will support. The defaults are four concurrent GCM clients and eight concurrent GCM servers. When these limits are reached, additional GCM client or GCM server connection requests are denied. You can alter these values by editing the GCM administration database from a privileged GCM client.

Remember to manually propagate the modified GCM administration database file GCM_ADMIN.EDB to all instances that are new to the association. If a GCM server was running previously but is new to this association, stop all GCM servers, manually copy the GCM administration database file, and then restart all GCM servers. Once you get your association set up and functioning, it is best not to alter it more than necessary. Once stability has been achieved, the GCM should remain stable and usable.

Customizing GCM

You can customize GCM in the following ways:

- Customize the GCM client application geometry.

  This includes window colors, sizes, and placement. This is accomplished using GCM client menu functions. See the GCM client help for more information.

- Customize connection attributes.

  These include the IP port assignment, whether to retrieve notices or banners upon connection, and various limits and diagnostic attributes. You can modify all these attributes from the GCM client. Note that if you change the IP port assignment, you must restart the GCM servers.

- Define custom commands.

  For a description, see "Defining and Using Commands" on page 151.

Defining and Using Commands

The GCM supports distributed execution of OpenVMS DCL commands and command procedures. However, at this time, the GCM does not support interactive commands and procedures. A DCL command that is a good candidate for execution using GCM has the following characteristics:

- It is immediately executed.
- It produces its output upon execution.
- It returns immediately.

Many DCL commands require a response from the user or do not return immediately. Such commands are not good candidates for use with GCM. For example, the RUN command does not always return immediately. The GCM server executes each command request within a subprocess but does not return any response to you; nor does the subprocess terminate if the program does not terminate. Therefore, to stop the subprocess you must enter a SHOW SYSTEM command to identify the associated subprocess to stop manually.

All GCM server commands are assigned subprocess names in the form GCM_*nodename*_CMD*nnnn* , where *nnnn* is a command sequence number. Typically, these subprocesses run to completion, delivering an AST to the GCM server to let it know that related output can be found in a temporary log file of the same name as the subprocess. After returning the result file, the subprocess and its related file are deleted. If the subprocess is executing a command that does not complete or that is waiting for input, the GCM server never sees command completion and never returns results. This does not prevent the GCM server from performing other duties, but it can lead to unexpected command behavior.

Future releases of GCM should provide additional command functionality. However, there will always be a class of command functionality that cannot be supported. Launching applications with graphical interfaces or complex interaction is beyond the intended use of GCM. In many cases, you can create a simple command procedure wrapper to allow an application to manage its own display redirection.

GCM Server Log Files

Several log files are generated as part of normal GCM server execution. Some of these log files are useful for GCM server troubleshooting (see "Troubleshooting the GCM Server" on page 152). Log files may include the system node name as part of the file specification as a means of isolating log files from individual system roots if the system disk is a cluster common system disk.

The following log files are generated:

- Run-time log files

  When a GCM server process is started, it creates the SYS$COMMON:[SYS$CONFIG]GCM_*nodename*_SERVER.LOG log file. This log file may contain details to help troubleshoot GCM server faults.

- Command log files

  An additional log file is created for each GCM server command that is executed. These log files have names in the following form:

  GCM_*nodename*_CMD*sequence_number*.LOG

  When a command executes successfully, the related log file is deleted. In rare cases, a GCM server fault may orphan one of these log files. At GCM server startup, any residual log files are deleted.

- Connection log files

  During run time, the GCM servers can be set to generate a connection log file. This optional file, SYS$COMMON:[SYS$CONFIG]GCM_*nodename*_CONNECT.LOG, contains a timestamped history of successful and failed GCM client connections.

  During run time, the GCM servers can be set to generate a GCM server event log. This optional file, SYS$COMMON:[SYS$CONFIG]GCM_*nodename*_EVENT.LOG, contains a wide variety of information that may help with GCM server troubleshooting. The content of this event log varies based on GCM server diagnostic flags. Event log entries typically are disabled to avoid generating excessively large files.

Troubleshooting the GCM Server

Any time that the GCM server is started using the normal startup procedure, it is running in a mode that supports automatic restart behavior. When run in its normal mode, the GCM server produces its run-time log file, but offers little additional information for troubleshooting possible GCM server problems.

The following sections contain information to assist you in troubleshooting possible GCM server problems.

Obtaining Diagnostic Information

At times it may be beneficial to run the GCM server in a mode that allows some diagnosis to occur. Diagnostics produce procedural trace information that is either written to the GCM server event log, if enabled, or output to the screen, if enabled. Typically, diagnostic output is directed to the screen; however, the event log output is useful if you need to forward it to HP support personnel for help.

To get diagnostic screen output from the GCM server, you must run the GCM server interactively rather than as a detached process. To do this, stop the GCM server if it is currently running, and restart it from a DECterm window by entering the following command:

```
$ RUN SYS$SYSTEM:GCM_SERVER.EXE
```

Once the GCM server is running, connect to it from a GCM client with administrative privileges, and edit the GCM administration database as follows:

1. Select Edit Admin Database from the File menu.
2. Select the Server Init page.
3. Locate the Diagnostic text field and note the buttons for selecting the desired output.

4. Click the Screen output button and enter the appropriate diagnostic code or codes, according to the following table. You can set more than one flag at a time.

Code (decimal)	Code (hex)	Function	Action
0	0	DIAGNOSTIC_DISABLE	Disables diagnostics.
1	1	HEARTBEAT_TRACE	Servers disconnecting.
2	2	TRANSACTION_TRACE	General troubleshooting.
4	4	XML_TRACE	General troubleshooting.
8	8	LOCK_TRACE	Server hangs.
16	10	COMMAND_TRACE	Disables execution and dumps packet.
32	20	CRYPTO_DISABLE	GCM administration database troubleshooting.

NOTE By default, regardless of whether the GCM client-server communications is using security (SSL), the GCM administration database is always encrypted. On rare occasions, you may want to disable encryption of the GCM administration database GCM administration database file. By setting the CRYPTO_DISABLE flag, GCM servers will no longer encrypt and update the GCM_ADMIN.EDB file. Instead, they will output plain ASCII XML to GCM_ADMIN.DAT, and will accept input on startup from GCM_ADMIN.DAT. This allows you to directly edit the XML structures within the GCM administration database and to review modifications made by the GCM client and server.

NOTE Run the GCM servers with the CRYPTO_DISABLE flag set only for troubleshooting because running the servers with this flag set exposes GCM user authorization records in simple ASCII unencrypted form.

Remember to disable diagnostics before returning a GCM server to service. If you do not disable logging, the related GCM server log files can grow very large and GCM server performance will suffer.

Potential Problem Areas

Heartbeats are a potential problem area for heavily loaded systems. For GCM servers to detect the presence and loss of GCM clients and GCM servers in other instances, periodic heartbeat transactions are issued. The GCM server is smart enough to optimize the heartbeat process, altering the rate based upon usage, and requiring only one-way heartbeats. At times, GCM server or network activity delays the issuance of a heartbeat. The GCM server is designed to tolerate a number of missed heartbeats before assuming disconnection.

You can tune heartbeat values to suit specific needs by using the GCM client to edit the GCM administration database. Three values apply: the Client Pulse, Server Pulse, and Flat Line. The Pulse values are the number of seconds between heartbeat transactions. The Flat Line value is how many heartbeats can be missed before

disconnection. These are preset to values that yield good behavior without undue traffic. Under special circumstances, you can alter these values if you find your sessions are being disconnected. These values have no effect on the overall responsiveness of the GCM with regard to command and event processing.

Timeout Detection

The GCM client contains a debug hook to turn off timeout detection entirely. To enter a debug mode, press Ctrl+Alt+D+B. A TEST menu item indicates this mode is active. In this mode the GCM client remains connected regardless of how long it takes to get a response back from a slow GCM server (such as one that is being debugged).

Performance

Because GCM is a client/server application, it is slower to respond to commands and configuration events than its native counterpart, the Galaxy Configuration Utility (GCU). While a Galaxy CPU assignment takes only a few milliseconds and is reflected immediately by the GCU, the GCM may take several seconds to update its display. For real-time response, run the GCU (and possibly multiple instances of the GCU if you have multiple hard partitions).

PC systems running Microsoft Windows require substantially more physical memory than may be present in a typical desktop PC. For best performance, your PC should have at least 128 MB (and preferably more). Disk space is seldom a concern.

The native OpenVMS GCM client does not perform quite as well as the Windows GCM client. On OpenVMS, user accounts must have substantial pagefile quota to run the GCM client. HP suggests that you set the PGFLQUO parameter to 350000 or more. (This is true of all Java applications on OpenVMS.)

Performance of GCM servers is typically a function of network behavior. GCM servers sit idle the majority of time, waking up every so often to issue a heartbeat transaction to other GCM servers or clients. The GCM server responds to configuration change events by reencoding the AlphaServer Configuration Tree structure in memory and then transmitting an XML- encoded representation to all active GCM servers and clients. This typically creates a burst of approximately 100 KB of network traffic. In an association that contains multiple GCM servers, with each server actively supporting GCM clients, the GCM servers must merge these bursts of data into a single configuration model, and then forward that model to each GCM client. The new model can require a megabyte or more.

To ensure optimal GCM performance, remember the following:

- Large configuration changes usually occur when GCM servers join or leave the association. Simple command processing produces far less traffic.
- The best way to ensure good GCM server performance is to limit the number of GCM servers in your association.
- You can define multiple associations to keep the size of any one association from growing excessively large.

Maintaining the GCM Server

In general, you do not need to perform maintenance tasks on the GCM server. However, if you have enabled some of the extended logging capabilities, the respective log files may grow quite large over time, and you may need to check these files periodically if you require such auditing. All such log files are found in the SYS$COMMON:[SYS$CONFIG] directory. The normal mode of operation disables logging.

The GCM client requires only the occasional cleanup of any library files that have been retrieved by the user. Each time a library file is retrieved, a copy is stored on the local GCM client system.

Sample Verbose GCM Server Setup

This section contains a sample verbose GCM server setup.

```
$ SET DEFAULT SYS$CONFIG
$ DIRECTORY

Directory SYS$COMMON:[SYS$CONFIG]

GCM$SETUP.EXE;1     GCM_BANNER.JPG;1    GCM_CERT.PEM;1      GCM_CUSTOM.XML;1
GCM_NOTICE.HTML;1   GCM_PRIVKEY.PEM;1   GCM_RULESET.XML;1

Total of 7 files.
$ RUN GCM$SETUP

OpenVMS GCM-Server Setup Utility
Copyright 2002, Hewlett Packard Corporation

 This utility initializes the GCM Administrative Database:
 SYS$COMMON:[SYS$CONFIG]GCM_ADMIN.EDB

 If you are performing an initial GCM-Server installation that will
 create an Association of more than a single server instance, you must
 perform the following tasks to assure proper server synchronization:

 1) Create the new local database using this utility.
 2) Copy the database to all other GCM-Server instances in your Association.
 3) Start each GCM-Server.

 You can start servers via $@SYS$STARTUP:GCMSRV$STARTUP.COM or by invoking
 this utility on each system.  When an existing database is found, this
 utility will offer additional server startup options.

 Continue (Y/N) {Y}?

 Do you prefer full text assistance (Y/N) {N}? y

 SERVER DISCOVERY TCP/IP PORT NUMBER:

 By default, the GCM-Servers listen for client connections on
 TCP/IP Port 4100.  This can be changed, but each server will need
 to be restarted, and each client will need to specify the new
 port number in their "Server Connection Preferences" settings.

 Use the default Port Number 4100 (Y/N) {Y}? y
```

```
 CONNECTION BOUNDS:

 By default, the GCM-Servers support up to 4 concurrent clients
 and 8 concurrent servers.  This can be changed, but each server
 will need to be restarted. Be advised that GCM performance may
 suffer as these values are increased.

 Use the default concurrent CLIENT limit of 4 (Y/N) {Y}? y

 Use the default concurrent SERVER limit of 8 (Y/N) {Y}? y

 CONNECTION SECURITY:

 By default, the GCM-Servers expect that their clients will be
 using secure connections (SSL).  This can be disabled, but the
 servers will need to be restarted, and each client will need
 to change their "Server Connection Preferences" settings.

 WARNING - DISABLING SECURITY COULD POTENTIALLY COMPROMISE THE
 INTEGRITY OF YOUR SYSTEM AND IS NOT RECOMMENDED BY HEWLETT PACKARD.

 Use SSL Client-Server Security (Y/N) {Y}? y

%SECURITY - WILL BE ENABLED.

 SERVER ASSOCIATION RECORD:

 Multiple GCM-Servers can form an "Association" of systems, providing
 a wide management scope.  This Association may include one server per
 soft-partition on one or more hard-partition on one or more physical
 system. Regardless of how many servers are in the Association, you
 need to define an Association Name that describes the involved systems.
 Choose a simple descriptive string such as "Engineering Lab Systems".

 Enter the Association Name (use no quotes): GCM Test Association

 SYSTEM RECORDS:

 Each system in the Association must be uniquely identified by its
 IP Address, System Number, Hard-Partition Number, and Soft Partition
 Number.  At least one system must be defined.  You may define multiple
 systems now, or define additional systems after establishing your
 first client connection.

 Enter a fully qualified name for the system running a GCM-Server.
 For example: star.zko.hp.com. When you are done entering system
 records, enter 0 at the following prompt.

 Enter a SYSTEM Name (ex: star.zko.hp.com) (RETURN when done): wfglx4.zko.hp.com

 Enter a fully qualified IP Address for the system running a
 GCM-Server.  For example: 16.32.112.16
 If you prefer to use DNS to lookup the address, enter 0

 Enter a System IP Address (0 to use DNS): 16.32.112.16

 The SYSTEM NUMBER is a simple numeric value that uniquely identifies
 soft and hard partitions that reside in a common partitionable
 computer.  For example, if you have two separate partitionable
 computers in your Association, each having its own hard and soft
 partitioned instances, enter a SYSTEM NUMBER of 0 for all hard and
 soft partitions in the first computer, and enter 1 for those in the
 second computer.
```

```
Enter a System Number (range 0-7): 0

The HARD PARTITION NUMBER is a numeric value that uniquely identifies
which HARD Partition a GCM-Server resides within.  If a system has
only a single HARD Partition, enter 0.  If a system has multiple
HARD Partitions, use the appropriate Hard Partition ID.  These are
sequential numeric values which were used when creating the system
partitions.  You can also obtain these values by running the Galaxy
Configuration Utility via $ CONFIG GALAXY command.

Enter a HARD PARTITION Number (range 0-7): 0

The SOFT PARTITION NUMBER is a numeric value that uniquely identifies
which SOFT Partition a GCM-Server resides within.  If a system has
only a single SOFT Partition, enter 0.  If a system has multiple
SOFT Partitions, use the appropriate Soft Partition ID.  These are
sequential numeric values which were used when creating the system
partitions.  You can also obtain these values by running the Galaxy
Configuration Utility via $ CONFIG GALAXY command.

Enter a SOFT PARTITION Number (range 0-7): 0

%Define additional system records as needed...

Enter a fully qualified name for the system running a GCM-Server.
For example: star.zko.hp.com. When you are done entering system
records, enter 0 at the following prompt.

Enter a SYSTEM Name (ex: star.zko.hp.com) (RETURN when done): wfglx5.zko.hp.com

Enter a fully qualified IP Address for the system running a
GCM-Server.  For example: 16.32.112.16
If you prefer to use DNS to lookup the address, enter 0

Enter a System IP Address (0 to use DNS): 16.32.112.17

The SYSTEM NUMBER is a simple numeric value that uniquely identifies
soft and hard partitions that reside in a common partitionable
computer.  For example, if you have two separate partitionable
computers in your Association, each having its own hard and soft
partitioned instances, enter a SYSTEM NUMBER of 0 for all hard and
soft partitions in the first computer, and enter 1 for those in the
second computer.

Enter a System Number (range 0-7): 0

The HARD PARTITION NUMBER is a numeric value that uniquely identifies
which HARD Partition a GCM-Server resides within.  If a system has
only a single HARD Partition, enter 0.  If a system has multiple
HARD Partitions, use the appropriate Hard Partition ID.  These are
sequential numeric values which were used when creating the system
partitions.  You can also obtain these values by running the Galaxy
Configuration Utility via $ CONFIG GALAXY command.

Enter a HARD PARTITION Number (range 0-7): 0

The SOFT PARTITION NUMBER is a numeric value that uniquely identifies
which SOFT Partition a GCM-Server resides within.  If a system has
only a single SOFT Partition, enter 0.  If a system has multiple
SOFT Partitions, use the appropriate Soft Partition ID.  These are
sequential numeric values which were used when creating the system
partitions.  You can also obtain these values by running the Galaxy
Configuration Utility via $ CONFIG GALAXY command.
```

```
Enter a SOFT PARTITION Number (range 0-7): 1

%Define additional system records as needed...

Enter a fully qualified name for the system running a GCM-Server.
For example: star.zko.hp.com. When you are done entering system
records, enter 0 at the following prompt.

Enter a SYSTEM Name (ex: star.zko.hp.com) (RETURN when done):

CLIENT AUTHORIZATION RECORDS:

At least one client must be defined in order to allow an initial
client-server connection to be established. Additional clients may
be defined now, or at any point using the client application and the
GCM Subscription Procedure.  This initial client record must provide
fully privileged access for the specified user so that subsequent
GCM administration functions can be performed.

Enter a string which describes this client.
The string can be the users full name, or job title, etc.

Enter Client's Full Name or Title (RETURN when done): First Last

Enter the clients USER name.  This is a single word that identifies
the user, such as their last name.

Enter Client's Username: First

Enter the clients PASSWORD.  This is a unique GCM password,
unrelated to any system authorization function.
Note: Passwords can be changed by any GCM-Client with Admin privilege.

Enter initial Password for First: Last

Enter the clients EMAIL Address.  This is particularly important
for the client that is serving the role of GCM Administrator as
they will receive email subscription requests.

Enter EMAIL Address for First: First.Last@hp.com

CONFIG privilege allows a user to issue commands that alter a system
configuration (if they also have the COMMAND privilege) and to load
and save configuration models.

Give First CONFIG Privilege (Y/N) {Y}? y

COMMAND privilege allows a user to issue DCL commands.

Give First COMMAND Privilege (Y/N) {Y}? y

USER-COMMAND privilege allows a user to create their own command
menu entries. Commands are executed in a privileged context so
use discretion when authorizing this privilege.

Give First USER-COMMAND Privilege (Y/N) {Y}? y

POWER privilege allows a user to issue commands that power on or off
system components for systems that support such operations.

Give First POWER Privilege (Y/N) {Y}? y

ADMIN privilege allows a user to modify the GCM-Server Administration
```

```
 Database.  Use discretion when authorizing this privilege.

 Give First ADMIN Privilege (Y/N) {Y}? y

 You may choose to ENABLE this client immediately, or enable the
 client later once the GCM is fully configured.
 IMPORTANT: Be sure to enable the initial administrator client!

 Enable First account now (Y/N) {Y}? y

 %Define additional client records as needed...

 Enter a string which describes this client.
 The string can be the users full name, or job title, etc.

 Enter Client's Full Name or Title (RETURN when done):

 SERVER STARTUP OPTIONS:

 You may choose to have the local GCM-Server started automatically upon
 system boot.  If you choose this option, the server will be started
 during the next system boot. To accomplish this, the startup file
 SYS$STARTUP:GCMSRV$STARTUP.COM will be added to the Layered Product
 startup database.

 Do you want the local GCM-SERVER to start on System Boot (Y/N) {Y}? y

 You may choose to start the local GCM-Server now, or you can start
 it later via $@SYS$STARTUP:GCMSRV$STARTUP.COM

 Do you want to start the local GCM-SERVER now (Y/N) {Y}? y


********************** POST SETUP TASKS *************************

 This completes the GCM Admin Database initialization.

 IMPORTANT:

 If you are using multiple GCM-Servers, copy the newly created GCM
 Admin Database file: SYS$COMMON:[SYS$CONFIG]GCM_ADMIN.EDB, to the
 same location on each system you defined in the Association, then
 start or restart each server via $ @SYS$STARTUP:GCMSRV$STARTUP.COM

 If the database has been properly defined, each server will detect
 the presence of the other servers and form the specified Association.
 If the GCM_SERVER process fails to start, examine the server logfile
 SYS$COMMON:[SYS$CONFIG]GCM_SERVER.LOG.

 When the server has started, you may use the GCM-Client to establish
 a connection and further tune the installation.

 For maximum security, you may wish to protect or remove this utility.

$
```

15 CPU Reassignment at the DCL CLI

OpenVMS supports several methods of managing CPU resources. The console establishes the default owner instance for each CPU using the console environment variables. This allows the CPU resources to be statically assigned, providing a precise initial configuration. In the event of a cold boot (that is, power cycle or initialization), this default configuration is restored from console nonvolatile RAM.

Once a configuration has been booted, OpenVMS provides more elegant means of assigning resources for users with the CMKRNL (Change Mode to Kernel) privilege. The following sections describe these methods.

DCL Reassignment

You can perform CPU reassignment operations if you have CMKRNL privilege using the following DCL command:

```
$ STOP/CPU/MIGRATE=instance-or-id   cpu-id
```

You must provide the target instance name (SCSNAME) or numeric ID (0, 1, and so on), and the numeric ID of the CPU being reassigned. The following examples show a few forms of this command:

```
$ STOP/CPU/MIGRATE=0  4       !Reassign CPU 4 to instance 0
$ STOP/CPU/MIGRATE=1  3,4,5   !Reassign CPUs 3,4,5 to instance 1
$ STOP/CPU 7/MIGRATE=BIGBNG   !ReassignCPU 7 to instance BIGBNG
$ STOP/CPU/ALL/MIGRATE=0      !Reassign all secondary CPUs to instance 0
```

You can insert these commands into command procedures. For example, you might want to move extra CPU resources to an instance in a startup procedure of an application with known processing requirements. Similarly, you may want to reassign CPUs away from an instance that is about to perform lengthy, I/O-intensive operations (such as backups) so that the CPUs are available to other instances. When the job completes, you may reassign them back or you may reassign CPUs away from an instance that is shutting down.

You can only reassign resources away from an instance. This is the push model defined by the Galaxy Software Architecture. This model prevents resources from being stolen by other instances that may not be aware of their current usage. To effectively manage the entire Galaxy system using DCL, you must either log in to each of the involved instances or use the SYSMAN utility to execute the commands on the owner instance.

GCU Drag-and-Drop Reassignment

The GCU provides an interactive visual interface for managing Galaxy resources. Using the GCU, you can reassign CPUs by dragging and dropping them among instances. Additionally, the GCU allows you to draw charts of various configurations (known as configuration models) and save them as files. At any time you can load and engage a configuration model, and the system reassigns resources as needed to achieve the desired model.

Intermodal Reassignment

Because of the resource push model defined by the Galaxy Software Architecture, resources must be given away by the Galaxy instance that currently owns them. For a utility or user to effectively manage resource assignment in a multiple-instance Galaxy configuration, you must establish some means of executing commands on each instance.

One such means is to open a window or terminal session on each of the Galaxy instances and perform your resource management operations in each of these windows.

Another method is use the SYSMAN utility and its underlying SMI server to establish a command environment on the owner instance. Using this method, you can write a fairly simple command procedure to perform specific resource management operations. This method has some limitations, however. First, it requires that the involved Galaxy instances must be in a cluster. Also, a command procedure cannot effectively pass variable parameters to SYSMAN environment scripts, and you cannot specify a remote system password within a SYSMAN script. Therefore, it is cumbersome to generate a general-purpose command procedure interface that uses SYSMAN.

The GCU does, in fact, use SYSMAN wherever possible to accomplish its management actions. When a system is not configured to support SYSMAN, the GCU attempts to use DECnet task-to-task communications among proxy accounts as its management transport. If that approach also fails (that is, if the system is not running DECnet or if the necessary proxy accounts are not set up), the GCU is not able to manage Galaxy instances other than the one on which the GCU is currently running. You can run multiple copies of the GCU if you choose, one per Galaxy instance. However, you can assume that OpenVMS Galaxy systems are likely to be clustered or to use DECnet.

The GCUs management actions are based in the SYS$MANAGER:GCU$ACTIONS.COM command procedure. You can modify this file to customize actions for your own environment. For example, in a TCP/IP environment, you may choose to use REXEC or a similar utility for your management transport, or you may want to include some form of notification or logging whenever a management action is executed.

The GCU$ACTIONS.COM file is somewhat unusual in the way it operates. When using SYSMAN, the procedure builds small SYSMAN command scripts in temporary files to deal with variable parameters that SYSMAN cannot handle. When SYSMAN is not available, the procedure attempts to open a DECnet task-to-task connection to a proxy account on the owner instance. If successful, it uses this connection to shuffle command parameters to the copy of GCU$ACTIONS.COM that resides on the owner instance. The end result is execution of the command locally by the owner instance.

Software Reassignment Using Galaxy Services

Perhaps the best method for managing resource assignment is to use the Galaxy APIs to write your own resource management routines. This allows you to base your decisions for resource management on your own criteria and application environment. The same push-model restriction described in Intermodal Reassignment still exists, however, so your routines need to be Galaxy aware, possibly using shared memory to coordinate their operations.

$CPU_TRANSITION[W] is an OpenVMS system service available to manage CPUs. $CPU_TRANSITION[W] changes the current processing state of a CPU in the configure set of the current system or an unassigned CPU in an OpenVMS Galaxy configuration.

Reassignment Faults

CPU reassignment can fail or be blocked for several reasons. Because the GCU buries its management actions in SYSMAN or DCL scripts, it may not always identify and report the reasons for a reassignment fault. The GCU does perform certain checks before allowing reassignment actions in order, for example, to prevent attempts to reassign the primary CPU. Other reasons exist for reassignment faults that can only be detected by the operating system or console firmware. For example, if the operating system detects a fault attempting to reassign a CPU that currently has process affinity or Fast Path duties, a DCL message is displayed on both the console and the users terminal.

The Galaxy APIs for reassignment are capable of reporting most faults to the caller. However, even using the reassignment services, the console may reject a reassignment because of hardware platform dependencies not readily visible to the operating system.

16 Galaxy and NUMA Commands and Lexicals

This chapter lists the DCL commands and lexical functions that are used for hot swap or hot add of CPUs and Galaxy setup. It also provides some usage examples. For additional information, refer to the *HP OpenVMS DCL Dictionary*. The commands fall into the following categories:

- CPU-Related DCL Commands, Table 16-1
- NUMA/RAD-Related DCL Commands, Table 16-2
- Galaxy-Related DCL Commands, Table 16-3
- Galaxy F$GETSYI Item Codes, Table 16-4
- Partitioning F$GETSYI Codes, Table 16-5
- SMP F$GETSYI Item Codes, Table 16-6
- RAD F$GETJPI Item Code, Table 16-7
- RAD F$GETSYI Item Codes, Table 16-8

CPU-Related DCL Commands

The tables on this and the next few pages describe DCL commands that are used for hot swap or hot add of CPUs.

Table 16-1 CPU-Related DCL Commands

Command	Qualifier	Description
SET CPU	/[NO]AUTO_START	Sets or clears the instance-specific autostart flag for the specified CPUs.
	/[NO]FAILOVER	Defines or removes any instance-specific failover relationship for the specified CPUs.
	/MIGRATE	Transfers ownership of the CPU from the current instance to another soft partition.
	/POWER	Turns the power on or off in one or more CPU slots. Valid options are ON and OFF.
	/REFRESH	Examines and updates the OpenVMS context for the specified CPU or CPUs, using the hardware configuration tree.

Table 16-1 CPU-Related DCL Commands (Continued)

Command	Qualifier	Description
	/OVERRIDE_CHECKS	Bypasses the series of checks that determine whether the specified processor is eligible for removal if the SET CPU command is being used to remove the CPU from the active set.
	/START	Initiates a request for the specified CPU to join the OpenVMS active set if it is not already there.
SHOW CPU	/ACTIVE_SET	Selects as the subject of the display only those processors that are members of the system's active set.
	/CONFIGURE_SET	Selects as the subject of the display only those processors that are members of the system's configure set — those that are actively owned and controlled by the current instance.
	/POTENTIAL_SET	Selects as the subject of the display only those processors that are members of the system's potential set — those CPUs in the hard partition that meet the current instance's requirements to join its active set. Inclusion in this set does not imply that the CPU is (or ever will be) owned by the current instance. The potential set only describes those physically existing CPUs that currently meet the instance-specific hardware and software compatibility constraints, should they ever become available.
	/STANDBY_SET	Selects as the subject of the display only those processors that are members of the system's standby set — those CPUs in the hard partition that are not currently owned by soft partitions and may be available for ownership by the current instance.
	/SYSTEM	Displays platform-specific hardware information relating to the current instance.
START/CPU	/POWER[=ON]	Powers on the CPU prior to bringing the CPU into the active set.
STOP/CPU	/MIGRATE	Transfers ownership of the CPU from the current instance to another soft partition.

Table 16-1 CPU-Related DCL Commands (Continued)

Command	Qualifier	Description
	/POWER=OFF	Powers down the CPU after it is removed from the active set.

Table 16-2 NUMA/RAD-Related DCL Commands

Command	Description
INITIALIZE/RAD=n	Specifies the RAD number on which to run batch jobs assigned to the queue.
SET ENTRY/RAD=n	Specifies the RAD number on which the submitted batch job is to execute.
SET PROCESS/RAD=HOME=n	Changes the home RAD of a process.
SET QUEUE/RAD=n	Specifies the RAD number on which to run batch jobs assigned to the queue.
SHOW PROCESS/RAD	Displays the home RAD.
START QUEUE/RAD=n	Specifies the RAD number on which to run batch jobs assigned to the queue.
SUBMIT/RAD=n	Specifies the RAD number on which the submitted batch job is to execute.

Table 16-3 Galaxy-Related DCL Commands

Command	Description
CONFIGURE GALAXY	Invokes the Galaxy Configuration Utility (GCU) to monitor, display, and interact with an OpenVMS Galaxy system.
INSTALL/LIST	Returns the Galaxywide sections as well as the standard global sections.
SHOW MEMORY/PHYSICAL	Displays the uses of memory by the system.

Galaxy-Related DCL Lexical Functions

This section describes DCL lexical function item codes F$GETSYI and F$GETJPI DCL used for Galaxy, Partitioning, SMP, and RAD setup.

Table 16-4 Galaxy F$GETSYI Item Codes

Item Code	Type	Description
GLX_MAX_MEMBERS	Integer	Returns the maximum count of instances that may join the current Galaxy configuration.
GLX_FORMATION	String	Returns a time-stamp string when the Galaxy configuration, of which this instance is a member, was created.
GLX_TERMINATION	String	Returns a time-stamp string when the Galaxy configuration, of which this instance last was a member, was terminated.
GLX_MBR_NAME	String	Returns a string indicating the names which are known in the Galaxy membership.
GLX_MBR_MEMBER	Integer	Returns a 64-byte integer. Each 8 bytes represents a Galaxy member, listed from 7 to 0. The value is 1 if the instance is currently a member, 0 if not a member.

Table 16-5 Partitioning F$GETSYI Item Codes

Item Code	Type	Description
HP_ACTIVE_CPU_CNT	Integer	Returns the count of CPUs in the hard partition that are not currently in firmware console mode. For OpenVMS this implies that the CPU is in, or in the process of joining, the active set in one of the instances in the hard partition.
HP_ACTIVE_SP_CNT	Integer	Returns the count of active operating system instances currently executing within the hard partition.
HP_CONFIG_SP_CNT	Integer	Returns the maximum count of soft partitions within the current hard partition. This count does not imply that an operating system instance is currently running within any given soft partition.
HP_CONFIG_SBB_CNT	Integer	Returns a count of the existing system building blocks within the current hard partition.

Table 16-6 SMP F$GETSYI Item Codes

Item Code	Type	Description
ACTIVE_CPU_MASK	Integer	Returns a value that represents a CPU-indexed bitvector. When a particular bit position is set, the processor with that CPU ID value is a member of the instance's active set - those currently participating in the OpenVMS SMP scheduling activities.
AVAIL_CPU_MASK	Integer	Returns a value that represents a CPU-indexed bitvector. When a particular bit position is set, the processor with that CPU ID value is a member of the instance's configure set - those owned by the partition and controlled by the issuing instance.
POTENTIAL_CPU_MASK	Integer	Returns a value that represents a CPU-indexed bitvector. When a particular bit position is set, the processor with that CPU ID value is a member of the instance's potential set. A CPU in the potential set implies that it could actively join the VMS active set for this instance if it is ever owned by it. To meet this rule the CPU's characteristics must match hardware and software compatibility rules defined particularly for that instance.
POWERED_CPU_MASK	Integer	Returns a value that represents a CPU-indexed bitvector. When a particular bit position is set, the processor with that CPU ID value is a member of the instance's powered set - those CPUs physically existing within the hard partition and powered up for operation.
PRESENT_CPU_MASK	Integer	Returns a value that represents a CPU-indexed bitvector. When a particular bit position is set, the processor with that CPU ID value is a member of the instance's present set - those CPUS physically existing within the hard partition.
CPUCAP_MASK	String	Returns a list of hexadecimal values, separated by commas and indexed by CPU ID. Each individual value represents a bitvector; when set, the corresponding user capability is enabled for that CPU.
PRIMARY_CPUID	Integer	Returns the CPU ID of the primary processor for this OpenVMS instance.
MAX_CPUS	Integer	Returns the maximum number of CPUs that could be recognized by this instance.
CPU_AUTOSTART	Integer	Returns a list of zeroes and ones, separated by commands and indexed by CPU ID. Any entry with a value of one indicates that specific CPU will be brought into the VMS active set if it transitions into the current instance from outside, or is powered up while already owned.
CPU_FAILOVER	Integer	Returns list of numeric partition IDs, separated by commas and indexed by CPU ID, that define the destination of the processor if the current instance should crash.

Table 16-6 SMP F$GETSYI Item Codes (Continued)

Item Code	Type	Description
POTENTIALCPU_CNT	Integer	The count of CPUs in the hard partition that are members of the potential set for this instance. A CPU in the potential set implies that it could actively join the VMS active set for this instance if it is ever owned by it. To meet this rule the CPU's characteristics must match hardware and software compatibility rules defined particularly for that instance.
PRESENTCPU_CNT	Integer	The count of CPUs in the hard partition that physically reside in a hardware slot.
POWEREDCPU_CNT	Integer	The count of CPUs in the hard partition that are physically powered up.

Table 16-7 RAD F$GETJPI Item Code

Item Code	Type	Description
HOME_RAD	Integer	Home resource affinity domain (RAD).

Table 16-8 RAD F$GETSYI Item Codes

Item Code	Type	Description
RAD_CPUS	Integer	Returns list of RAD,CPU pairs, separated by commas.
RAD_MEMSIZE	Integer	Returns list of RAD,PAGES pairs, separated by commas.
RAD_MAX_RADS	Integer	Returns the maximum number of RADS possible on this platform. The value is always 8 (regardless of number of quad building blocks (QBBs) physically present).
RAD_SHMEMSIZE	Integer	Returns list of RAD,PAGES pairs, separated by commas.

DCL Command Examples

The DCL commands and lexical functions in this section are useful for managing an OpenVMS Galaxy. They are described with examples in the following order:

- STOP/CPU/MIGRATE (see page 171)
- SHOW CPU (see page 171)
- SET CPU (see page 172)
- SHOW MEMORY (see page 172)
- Lexical functions (see page 173)
- INSTALL LIST (see page 173)

- INSTALL ADD (see page 173)
- CONFIGURE GALAXY (see page 173)

These commands are described in the following sections.

CPU Commands

CPUs are assignable resources in an OpenVMS Galaxy. You can assign CPUs using either the Physical Structure chart (see "Physical Structure Chart" on page 123) or the STOP/CPU/MIGRATE command (STOP/CPU/MIGRATE).

STOP/CPU/MIGRATE

The STOP/CPU/MIGRATE command transfers ownership of the CPU from the current instance to another soft partition.

For example, enter:

```
$ STOP/CPU/MIGRATE=GLXSYS  4
```

In this example, GLXSYS can be an instance name or a partition ID value. No operating system is required to be running at the target.

The following message is displayed at the terminal:

```
%SYSTEM-I-CPUSTOPPING, trying to stop CPU 4 after it reaches quiescent
state
```

The source console displays:

```
%SMP-I-STOPPED, CPU #04 has been stopped.
```

The destination console displays:

```
%SMP-I-SECMSG, CPU #04 message:   P04>>>START
%SMP-I-CPUTRN, CPU #04 has joined the active set.
```

SHOW CPU

The SHOW CPU command displays information about the status, characteristics, and capabilities of the specified processors. For example:

```
$ show cpu

System: GLXSYS, Compaq AlphaServer GS320 6/731

CPU ownership sets:
   Active               0-31
   Configure            0-31

CPU state sets:
   Potential            0-31
   Autostart            0-31
   Powered Down         None
   Failover             None

$ show cpu/system

System: GLXSYS, Compaq AlphaServer GS320 6/731

  SMP execlet   = 2 : Enabled : Full checking.
```

```
  Config tree    = Version 6
  Primary CPU    = 0
  HWRPB CPUs     = 32
  Page Size      = 8192
  Revision Code =
  Serial Number = BUDATEST
  Default CPU Capabilities:
        System: QUORUM RUN
  Default Process Capabilities:
        System: QUORUM RUN

CPU ownership sets:
   Active               0-31
   Configure            0-31

CPU state sets:
   Potential            0-31
   Autostart            0-31
   Powered Down         None
   Failover             None
```

SET CPU

The SET CPU command changes the user capabilities associated with the specified CPUs.

In the following commands, *n* represents the CPU number, a comma-separated list of CPUs, or the /ALL qualifier.

- SET CPU *n*/FAILOVER=*y*

  Establishes instance-specific failover relationships for each CPU in the instance's potential set. When the instance crashes, CPUs with a failover target other than the current instance will be assigned or migrated to that target.

  y is the name of an instance or a physical partition ID within the current hard partition.

- SET CPU *n*/NOFAILOVER

  Removes any instance-specific failover relationships for the specified CPUs.

- SET CPU *n*/AUTO_START

  Sets or clears the instance-specific autostart flag for the specified CPUs.

  When autostart is enabled, that CPU will join the OpenVMS active set when it is assigned or migrated into the partition. The CPU will also autostart if a power-up transition is completed while the CPU is owned by the issuing instance.

- SET CPU *n*/NOAUTO_START

  Clears the instance-specific autostart flag for the specified CPUs.

SHOW MEMORY

The SHOW MEMORY command displays the uses of memory by the system. For example:

```
$ SHOW MEMORY/PHYSICAL

            System Memory Resources on 5-OCT-2001 20:50:19.03

Physical Memory Usage (pages):     Total        Free      In Use    Modified
   Main Memory (2048.00Mb)        262144        228183    31494      2467
```

```
Of the physical pages in use, 11556 pages are permanently allocated to OpenVMS.

$ SHOW MEMORY/PHYSICAL

              System Memory Resources on 5-OCT-2001 07:55:14.68

Physical Memory Usage (pages):     Total        Free      In Use    Modified
   Private Memory (512.00Mb)       65536        56146      8875         515
   Shared Memory (1024.00Mb)       131072       130344      728

Of the physical pages in use, 6421 pages are permanently allocated to OpenVMS.
$
```

Lexical Function Example

A lexical function is a function that returns information about character strings and attributes of the current process. The following command procedure uses the F$GETSYI lexical function to create a command procedure to show you the attributes of a Galaxy system:

Lexical Function Example Command Procedure

```
$ create shoglx.com
$ write sys$output ""$ write sys$output "Instance = ",f$getsyi("scsnode")
$ write sys$output "Platform = ",f$getsyi("galaxy_platform")
$ write sys$output "Sharing Member = ",f$getsyi("galaxy_member")
$ write sys$output "Galaxy ID = ",f$getsyi("galaxy_id")
$ write sys$output "Community ID = ",f$getsyi("community_id")
$ write sys$output "Partition ID = ",f$getsyi("partition_id")
$ write sys$output ""$ exit
$ ^Z
```

Lexical Function Command Procedure Output

```
$ @SHOGLX

Instance = COBRA2
Platform = 1
Sharing Member = 1
Galaxy ID = 5F5F30584C47018011D3CC8580F40383
Community ID = 0
Partition ID = 0

$
```

INSTALL LIST

The INSTALL LIST command now returns all of the Galaxy sections as well as standard global sections.

INSTALL ADD/WRITABLE

The INSTALL ADD/WRITABLE command now supports Galaxy sections as well as standard global sections. INSTALL ADD/WRITABLE=GALAXY installs the specified file as a writable known image in a Galaxy global section.

CONFIGURE GALAXY

The CONFIGURE GALAXY command invokes the Galaxy Configuration Utility (GCU) to monitor, display, and interact with an OpenVMS Galaxy system. The GCU requires DECwindows Motif Version 1.2-4 or higher and OpenVMS Alpha Version 7.2 or higher.

The optional model parameter specifies the location and name of a Galaxy Configuration Model to load and display. If no model is provided and the system is running as an OpenVMS Galaxy, the current active configuration is displayed.

If the system is not running as an OpenVMS Galaxy, the GCU will assist the user in creating a single-instance OpenVMS Galaxy system.

OpenVMS Galaxy Configuration Models are created using either the Galaxy Configuration Utility (GCU) or the Graphical Configuration Manager (GCM). See the GCU or GCM online help for more information.

Format:

CONFIGURE GALAXY [*model*.GCM]

Parameter:

`GALAXY [model.GCM]`

Specifies the location and name of a Galaxy configuration model to load and display.

If no model is provided and the system is running as an OpenVMS Galaxy, the current active configuration is displayed.

Qualifiers:

/ENGAGE

Causes the GCU to engage (load, validate, and activate) the specified OpenVMS Galaxy Configuration Model without displaying the graphical user interface. After validation, the specified model becomes the active system configuration.

This qualifier allows system managers to restore the OpenVMS Galaxy system to a known configuration, regardless of what dynamic resource reassignments may have occurred since the system was booted. This command can be embedded in DCL command procedures to automate configuration operations.

/VIEW

When used in conjunction with /ENGAGE and a model parameter, causes the GCU to load, validate, activate, and display the specified configuration model.

Examples:

```
$ CONFIGURE GALAXY
```

Displays the GCU's graphical user interface. If the system is currently configured as an OpenVMS Galaxy, the active system configuration is displayed.

```
$ CONFIGURE GALAXY model.GCM
```

Displays the GCU's graphical user interface. The specified OpenVMS Galaxy Configuration Model is loaded and displayed, but does not become the active configuration until the user chooses to engage it.

```
$ CONFIGURE GALAXY/ENGAGE model.GCM
```

Invokes the GCU command-line interface to engage the specified OpenVMS Galaxy Configuration Model without displaying the GCU's graphical user interface.

```
$ CONFIGURE GALAXY/ENGAGE/VIEW model.GCM
```

Invokes the GCU command-line interface to engage the specified OpenVMS Galaxy Configuration Model and display the GCU's graphical user interface.

17 Communicating With Shared Memory

This chapter describes the following two OpenVMS internal mechanisms that use shared memory to communicate between instances in an OpenVMS Galaxy computing environment:

- Shared Memory Cluster Interconnect (SMCI)
- Local area network (LAN) shared memory device driver

Shared Memory Cluster Interconnect (SMCI)

The Shared Memory Cluster Interconnect (SMCI) is a System Communications Services (SCS) port for communications between Galaxy instances. When an OpenVMS instance is booted as both a Galaxy and an OpenVMS Cluster member, the SMCI driver is loaded. This SCS port driver communicates with other cluster instances in the same Galaxy through shared memory. This capability provides one of the major performance benefits of the OpenVMS Galaxy Software Architecture. The ability to communicate to another clustered instance through shared memory provides dramatic performance benefits over traditional cluster interconnects.

The following sections discuss drivers and devices that are used with SMCI.

SYS$PBDRIVER Port Devices

When booting as both a Galaxy and a cluster member, SYS$PBDRIVER is loaded by default. The loading of this driver creates a device PBA*x*, where *x* represents the Galaxy partition ID. As other instances are booted, they also create PBA*x* devices. The SMCI quickly identifies the other instances and creates communications channels to them. Unlike traditional cluster interconnects, a new device is created to communicate with the other instances. This device also has the name PBA*x*, where *x* represents the Galaxy partition ID for the instance with which this device is communicating.

For example, consider an OpenVMS Galaxy that consists of two instances: MILKY and WAY. MILKY is instance 0 and WAY is instance 1. When node MILKY boots, it creates device PBA0. When node WAY boots, it creates PBA1. As the two nodes find each other, MILKY creates PBA1 to talk to WAY and WAY creates PBA0 to talk to MILKY.

```
MILKY                   WAY

PBA0:                   PBA1:

PBA1:    <-------->     PBA0:
```

Multiple Clusters in a Single Galaxy

SYS$PBDRIVER can support multiple clusters in the same Galaxy. This is done in the same way that SYS$PEDRIVER allows support for multiple clusters on the same LAN. The cluster group number and password used by SYS$PEDRIVER are also used by SYS$PBDRIVER to distinguish different clusters in the

same Galaxy community. If your Galaxy instances are also clustered with other OpenVMS instances over the LAN, the cluster group number is set appropriately by CLUSTER_CONFIG. To determine the current cluster group number, enter:

```
$ MCR SYMAN
SYSMAN> CONFIGURATION SHOW CLUSTER_AUTHORIZATION
Node: MILKY   Cluster group number: 0
Multicast address: xx-xx-xx-xx-xx-xx
SYSMAN>
```

If you are not clustering over a LAN and you want to run multiple clusters in the same Galaxy community, then you must set the cluster group number. You must ensure that the group number and password are the same for all Galaxy instances that you want to be in the same cluster as follows:

```
$ MCR SYSMAN
SYSMAN> CONFIGURATION SET CLUSTER_AUTHORIZATION/GROUP_NUMBER=222/PASSWORD=xxxx
SYSMAN>
```

If your Galaxy instances are also clustering over the LAN, CLUSTER_CONFIG asks for a cluster group number, and the Galaxy instances use that group number. If you are not clustering over a LAN, the group number defaults to zero. This means that all instances in the Galaxy are in the same cluster.

SYSGEN Parameters for SYS$PBDRIVER

In most cases, the default settings for SYS$PBDRIVER should be appropriate; however, several SYSGEN parameters are provided. Two SYSGEN parameters control SYS$PBDRIVER: SMCI_PORTS and SMCI_FLAGS.

SMCI_PORTS

The SYSGEN parameter SMCI_PORTS controls the initial loading of SYS$PBDRIVER. This parameter is a bit mask in which bits 0 through 25 each represent a controller letter. If bit 0 is set, PBA*x* is loaded; this is the default setting. If bit 1 is set, PBB*x* is loaded, and so on all the way up to bit 25, which causes PBZ*x* to be loaded. For OpenVMS Alpha Version 7.3–1 and later, HP recommends leaving this parameter at the default value of 1.

Loading additional ports allows for multiple paths between Galaxy instances. For OpenVMS Alpha Version 7.3–1, having multiple communications channels does not provide any advantages because SYS$PBDRIVER does not support Fast Path. A future release of OpenVMS will provide Fast Path support for SYS$PBDRIVER. When Fast Path support is enabled, instances with multiple CPUs can achieve improved throughput by having multiple communications channels between instances.

SMCI_FLAGS

The SYSGEN parameter SMCI_FLAGS controls operational aspects of SYS$PBDRIVER. The only currently defined flag is bit 1. Bit 1 controls whether or not the port device supports communications with itself. Supporting SCS communications to itself is primarily used for test purposes. By default, this bit is turned off and thus support for SCS communication locally is disabled, which saves system resources. This parameter is dynamic and by turning this bit on, an SCS virtual circuit should soon form.

The following table shows the values of the bits and the bit mask in the SMCI_FLAGS parameter.

Bit	Mask	Description
0	0	0 = Do not create local communications channels (SYSGEN default). Local SCS communications are primarily used in test situations and not needed for normal operations. Leaving this bit off saves resources and overhead. 1 = Create local communications channels.
1	2	0 = Load SYS$PBDRIVER if booting into both a Galaxy and a Cluster (SYSGEN Default). 1 = Load SYS$PBDRIVER if booting into a Galaxy.
2	4	0 = Minimal console output (SYSGEN default). 1 = Full console output, SYS$PBDRIVER displays console messages when creating communication channels and tearing down communication channels.

LAN Shared Memory Device Driver

Local area network (LAN) communications between OpenVMS Galaxy instances are supported by the Ethernet LAN shared memory driver. This LAN driver communicates to other instances in the same OpenVMS Galaxy system through shared memory. Communicating with other instances through shared memory provides performance benefits over traditional LANs.

To load the LAN shared memory driver SYS$EBDRIVER, enter the following command:

```
$ MCR SYSMAN
SYSMAN> IO CONN EBA/DRIVER=SYS$EBDRIVER/NOADAPTER
```

For OpenVMS Version 7.3–1 and later, in order for LAN protocols to automatically start over this LAN device (EBA*n*, where *n* is the unit number), the procedure for loading this driver should be added to the configuration procedure:

`SYS$MANAGER:SYCONFIG.COM`.

The LAN driver emulates an Ethernet LAN with frame formats the same as Ethernet/IEEE 802.3 but with maximum frame size increased from 1518 to 7360 bytes. The LAN driver presents a standard OpenVMS QIO and VCI interface to applications. All existing QIO and VCI LAN applications should work unchanged.

In a future release, the SYS$EBDRIVER device driver will be loaded automatically.

18 Shared Memory Programming Interfaces

A **shared memory global section** maps some amount of memory that can be accessed on all instances in a sharing community. These objects are also called **Galaxy-wide shared sections**. Each such object has a name, a version, and protection characteristics.

Using Shared Memory

Application programs access shared memory by mapping Galaxy-wide shared sections. The programming model is the same as for standard OpenVMS global sections; that is, you create, map, unmap, and delete them on each instance where you want to use them. Some shared memory global section characteristics are:

- Pages start out as demand zero with preallocated shared PFNs.
- Pages are not counted against your working set.
- Once the page is valid in your process' page table, it stays valid until it is deleted; shared memory section pages are never paged to disk.
- You must create the shared section on each instance where you want to access shared memory.
- Sections can be temporary or permanent.
- Sections can be group or system global sections.
- Galaxy-wide shared sections use a different name space than traditional global sections.
- Section versions specified in the ident_64 field are validated throughout the Galaxy.
- Only one shared section with a given name and UIC group can exist in a sharing community. This is different from traditional global sections, in which multiple versions can coexist.
- The SHMEM privilege is required to create a shared memory section.

From a programmer's point of view, shared memory global sections are similar to memory resident sections. You use the same system services to create Galaxy-wide shared sections that you would use to create memory resident sections. Setting the flag SEC$M_SHMGS lets the service operate on a shared memory global section.

In contrast to memory resident sections, the Reserved Memory Registry is not used to allocate space for Galaxy-wide sections. The SYSMAN RESERVE commands affect only node-private memory. Shared memory is not used for normal OpenVMS paging operations and does not need to be reserved.

There is also no user interface to specify whether shared page tables should be created for Galaxy-wide sections. Instead, the creation of shared page tables for Galaxy-wide sections is tied to the section size. As of OpenVMS Version 7.2, shared page tables are created for sections of 128 pages (1 MB) or more. Galaxy-wide shared page tables are shared between all Galaxy instances.

System Services

The following sections describe new and changed system services that support shared memory global sections.

Enhanced Services

The following system services have been enhanced to recognize the new shared memory global section flag SEC$M_SHMGS:

- SYS$CRMPSC_GDZRO_64
- SYS$CREATE_GDZRO
- SYS$MGBLSC_64
- SYS$DGBLSC

The following system services have been enhanced to work with shared memory, but no interfaces were changed:

- SYS$DELTVA
- SYS$DELTVA_64
- SYS$CREATE_BUFOBJ
- SYS$CREATE_BUFOBJ_64
- SYS$DELETE_BUFOBJ

New Section Flag SEC$M_READ_ONLY_SHPT

The new section flag SEC$M_READ_ONLY_SHPT is recognized by the SYS$CREATE_GDZRO and SYS$CRMPSC_GDZRO_64 services. When this bit is set, it directs the system to create shared page tables for the sections that allow read access only. This feature is particularly useful in an environment where a memory resident or Galaxy shared section is used by many readers but only a single writer.

When you map a Galaxy shared section or a memory resident section that has an associated shared page table section, you have the following options for accessing data:

Shared Page Tables	Read Only	Read and Write
None created	Do not set the SEC$M_WRT flag in the map request. Private page tables are always used, even if you specify a shared page table region into which to map the section.	Set the SEC$M_WRT flag in the map request. Private page tables are used, even if you specify a shared page table region into which to map the section.

Shared Page Tables	Read Only	Read and Write
Write access	Do not set the SEC$M_WRT flag in the map request. Ensure that private page tables are used. Do not specify a shared page table region into which to map the section. If you do, the error status SS$_IVSECFLG is returned.	Set the SEC$M_WRT flag in the map request. The shared page table section is used for mapping if you specify a shared page table region into which to map the section.
Read access	Do not set the SEC$M_WRT flag in the map request. The shared page table section is used for mapping if you specify a shared page table region into which to map the section.	Set the SEC$M_WRT flag in the map request. Ensure that private page tables is used. Do not specify a shared page table region into which to map the section. If you do, the error status SS$_IVSECFLG is returned.

NOTE Shared page tables for Galaxy shared sections are also implemented as Galaxy shared sections. This implies that they allow either read access only on all OpenVMS instances connected to this section or read and write access on all instances. The setting of the SEC$M_READ_ONLY_SHPT flag as requested by the first instance to create the section is used on all instances.

Using the SYS$CRMPSC_GDZRO_64 service always implies that the SEC$M_WRT flag is set and that you want to map the section for writing. If you want to use this service to create a section with shared page tables for read-only access, you must use private page tables and you cannot specify a shared page table region into which to map the section.

Galaxy-wide Global Sections

The SHMEM privilege is required to create an object in Galaxy shared memory. The right to map to an existing section is controlled through normal access control mechanisms. SHMEM is not needed to map an existing section. Note that the VMS$MEM_RESIDENT_USER identifier, which is needed to create an ordinary memory resident section, is not required for Galaxy-wide sections.

Creating and mapping Galaxy-wide memory sections is accomplished through the same services used to create memory resident sections. The following services now recognize the SEC$M_SHMGS flag:

- SYS$CREATE_GDZRO
- SYS$CRMPSC_GDZRO_64
- SYS$MGBLSC_64
- SYS$DGBLSC

SYS$CREATE_GDZRO and SYS$CRMPSC_GDZRO_64 can also return new status codes.

Status Code	Description
SS$_INV_SHMEM	Shared memory is not valid.

Status Code	Description
SS$_INSFRPGS	Insufficient free shared pages or private pages.
SS$_NOBREAK	A Galaxy lock is held by another node and was not broken.
SS$_LOCK_TIMEOUT	A Galaxy lock timed out.

The INSTALL LIST/GLOBAL and SHOW MEMORY commands are also aware of Galaxy-wide sections.

Galaxy-wide sections are using their own name space. Just as you could always use the same name to identify system global sections and group global sections for various owner UICs, you can now also have Galaxy-wide system global sections and Galaxy-wide group global sections all with the same name.

Galaxy-wide sections also have their own security classes:

- GLXSYS_GLOBAL_SECTION
- GLXGRP_GLOBAL_SECTION

These security classes are used with the $GET_SECURITY and $SET_SECURITY system services, and DCL commands SET/SHOW SECURITY.

These new security classes are only valid in a Galaxy environment. They are not recognized on a non-Galaxy node.

You can only retrieve and affect security attributes of Galaxy-wide global sections if they exist on your sharing instance.

Audit messages for Galaxy-wide sections look like this:

```
%%%%%%%%  OPCOM  20-MAR-2002 10:44:43.71  %%%%%%%% (from node GLX1 at 20-MAR-2002 10:44:43.85)
Message from user AUDIT$SERVER on GLX1
Security alarm (SECURITY) on GLX1, system id: 19955
Auditable event:          Object creation
Event information:        global section map request
Event time:               20-MAR-2002 10:44:43.84
PID:                      2040011A
Process name:             ANDY
Username:                 ANDY
Process owner:            [ANDY]
Terminal name:            RTA1:
Image name:               MILKY$DKA100:[ANDY]SHM_MAP.EXE;1
Object class name:        GLXGRP_GLOBAL_SECTION
Object name:              [47]WAY____D99DDB03_0$MY_SECTION
Secondary object name:    <Galaxywide global section >
Access requested:         READ,WRITE
Deaccess key:             8450C610
Status:                   %SYSTEM-S-CREATED, file or section did not exist;
                          has been created
```

Note the "Object name" field: the object name displayed here uniquely identifies the section in the OpenVMS Galaxy. The fields are as follows:

[47]	(only for group global sections) Identifies the UIC group of the section creator.
WAY____D99DDB03_0$	An identifier for the sharing community.
MY_SECTION	The name of the section as specified by the user.

The user can only specify the section name and class for requests to set or show the security profile. The UIC is always obtained from the current process and the community identifier is obtained from the community in which the process executes.

The output for a Galaxy-wide system global section differs only in the fields "Object class name" and "Objects name." The object name for this type of section does not include a group identification field:

Object class name:	GLXSYS_GLOBAL_SECTION
Object name:	WAY____D99DDB03_0$SYSTEM_SECTION

NOTE **Security Notes:**

Security attributes for a Galaxy-wide memory section must appear identical to a process, no matter on what instance it is executing.

This can be achieved by having all instances participating in this sharing community also participate in a homogeneous OpenVMS Cluster, where all nodes share the security-related files:

- SYSUAF.DAT, SYSUAFALT.DAT (system authorization file)
- RIGHTSLIST.DAT (rights database)
- VMS$OBJECTS.DAT (objects database)

In particular, automatic propagation of protection changes to a Galaxy-wide section requires that the same physical file (VMS$OBJECTS.DAT) is used by all sharing instances.

If your installation does not share these files throughout the Galaxy, the creator of a Galaxy-wide shared section must ensure that the section has the same security attributes on each instances. This may require manual intervention.

---

19 OpenVMS Galaxy Device Drivers

This chapter describes OpenVMS Alpha Version 7.3 direct-mapped DMA window information for PCI drivers.

Direct-Mapped DMA Window Changes

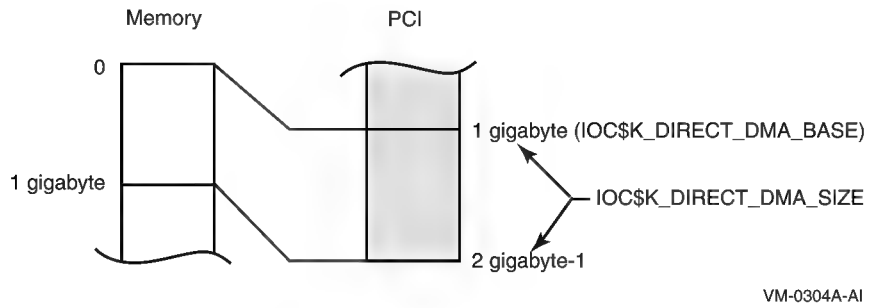
The changes described in this chapter were made in OpenVMS Version 7.2 to support OpenVMS Galaxy and memory holes. The change involves moving the direct-mapped DMA window away from physical memory location 0. This chapter should provide enough background and information for you to update your driver if you have not yet updated it to OpenVMS Version 7.2 or later.

Note that this chapter does not cover the bus-addressable pool (BAP).

How PCI Direct-Mapped DMA Works Prior to OpenVMS Version 7.2

On all PCI-based machines, the direct-mapped DMA window begins at (usually) 1 GB in PCI space and covers physical memory beginning at 0 for 1 GB as shown in Figure 19-1.

Figure 19-1 PCI-Based DMA



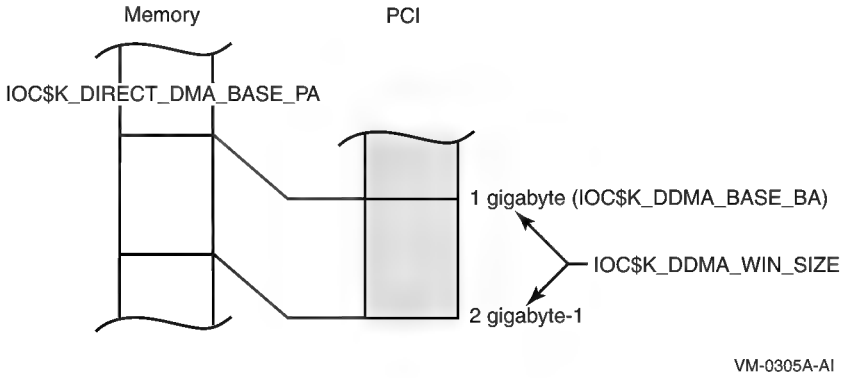
Typically, drivers compare their buffer addresses against the length of the window returned by calling IOC$NODE_DATA with the IOC$K_DIRECT_DMA_SIZE function code. This assumes that the window on the memory side starts at zero. Another popular method for determining whether map registers are necessary involves looking at MMG$GL_MAXPFN. This is also not likely to work correctly in OpenVMS Version 7.3.

For a much better picture and explanation, see the *Writing OpenVMS Alpha Device Drivers in C* book.

How PCI Direct-Mapped DMA Works in Current Versions of OpenVMS

Galaxy and memory-hole considerations force OpenVMS to change the placement of the direct-mapped DMA window, as shown in Figure 19-2.

Figure 19-2 OpenVMS DMA



It is unknown from the driver's perspective where in memory the base of the direct-mapped DMA window will be. Simply comparing a buffer address against the length of the window is not enough to determine whether a buffer is within the direct-mapped DMA window. Also, comparing against MMG$GL_MAXPFN will no longer guarantee that all of the pool is within the window. The correct cell to check is MMG$GL_MAX_NODE_PFN. Additionally, alignment concerns may require that a slightly different offset be incorporated into physical bus address calculations.

IOC$NODE_DATA Changes to Support Nonzero Direct-Mapped DMA Windows

To alleviate this problem, new function codes have been added to IOC$NODE_DATA. Here is a list of all the codes relating to direct-mapped DMA, and a description of what the data means.

Code	Description
IOC$K_DIRECT_DMA_BASE	This is the base address on the PCI side, or bus address. There is a synonym for this function code called IOC$K_DDMA_BASE_BA. A 32-bit result will be returned.
IOC$DIRECT_DMA_SIZE	On non-Galaxy machines, this returns the size of the direct-mapped DMA window (in megabytes). On a system where the direct-mapped DMA window does not start at zero, the data returned is zero, implying that no direct-mapped DMA windows exist. A 32-bit result will be returned.

Code	Description
IOC$K_DDMA_WIN_SIZE	On all systems, this will always return the size of the direct-mapped DMA window (in megabytes). A 32-bit result will be returned.
IOC$K_DIRECT_DMA_BASE_PA	This is the base physical address in memory of the direct-mapped DMA window. A 32-bit result will be returned.

The address returned with the IOC$K_DIRECT_DMA_BASE_PA code is necessary to compute the offset. (This usually used to be the 1 GB difference between the memory PA and the bus address.) The offset is defined as the signed difference between the base bus address and the base memory address. This is now not necessarily 1 gigabyte.

A OpenVMS Galaxy CPU Load Balancer Program

This appendix contains an example program of a privileged-code application that dynamically reassigns CPU resources among instances in an OpenVMS Galaxy.

CPU Load Balancer Overview

The OpenVMS Galaxy CPU Load Balancer program is a privileged application that dynamically reassigns CPU resources among instances in an OpenVMS Galaxy.

The program must be run on each participating instance. Each image creates, or maps to, a small shared memory section and periodically posts information regarding the depth of that instance's COM queues. Based upon running averages of this data, each instance determines the most and the least busy instances. If these factors exist for a specified duration, the least busy instance having available secondary processors reassigns one of its processors to the most busy instance, thereby effectively balancing processor usage across the OpenVMS Galaxy. The program provides command-line arguments to allow tuning of the load-balancing algorithm. The program is admittedly shy on error handling.

This program uses the following OpenVMS Galaxy system services:

Service	Description
SYS$CPU_TRANSITION	CPU reassignment
SYS$CRMPSC_GDZRO_64	Shared memory creation
SYS$SET_SYSTEM_EVENT	OpenVMS Galaxy event notification
SYS$*_GALAXY_LOCK_*	OpenVMS Galaxy locking

Because OpenVMS Galaxy resources are always reassigned via a push model, where only the owner instance can release its resources, one copy of this process must run on each instance in the OpenVMS Galaxy.

This program can be run only in an OpenVMS Version 7.2 or later multiple-instance Galaxy.

Required Privileges

The CMKRNL privilege is required to count CPU queues. The SHMEM privilege is required to map shared memory.

Build and Copy Instructions

Compile and link the example program as described in the following section, or copy the precompiled image found in SYS$EXAMPLES:GCU$BALANCER.EXE to SYS$COMMON:[SYSEXE]GCU$BALANCER.EXE.

If your OpenVMS Galaxy instances use individual system disks, you need to perform this action for each instance.

If you change the example program, compile and link it as follows:

```
$ CC GCU$BALANCER.C+SYS$LIBRARY:SYS$LIB_C/LIBRARY
$ LINK/SYSEXE GCU$BALANCER
```

Startup Options

You must establish a DCL command for this program. HP has provided a sample command table file for this purpose. To install the new command, enter the following:

```
$ SET COMMAND/TABLE=SYS$LIBRARY:DCLTABLES -
_$ /OUT=SYS$COMMON:[SYSLIB]DCLTABLES GCU$BALANCER.CLD
```

This command inserts the new command definition into DCLTABLES.EXE in your common system directory. The new command tables take effect when the system is rebooted. If you would like to avoid a reboot, enter the following:

```
$ INSTALL REPLACE SYS$COMMON:[SYSLIB]DCLTABLES.EXE
```

After this command, you need to log out and log back in to use the command from any active processes. Alternatively, if you would like to avoid logging out, enter the following from each process you would like to run the balancer from:

```
$ SET COMMAND GCU$BALANCER.CLD
```

Once your command has been established, you may use the various command-line parameters to control the balancer algorithm.

```
$ CONFIGURE BALANCER[/STATISTICS] x y time
```

In this command, *x* is the number of load samples to take, *y* is the number of queued processes required to trigger resource reassignment, and *time* is the delta time between load sampling.

The /STATISTICS qualifier causes the program to display a continuous status line. This is useful for tuning the parameters. This output is not visible if the balancer is run detached, as is the case if it is invoked via the GCU. The /STATISTICS qualifier is intended to be used only when the balancer is invoked directly from DCL in a DECterm window. For example:

```
$ CONFIG BAL 3 1 00:00:05.00
```

This starts the balancer, which samples the system load every 5 seconds. After three samples, if the instance has one or more processes in the COM queue, a resource (CPU) reassignment occurs, giving this instance another CPU.

Example Program

```
/*
** COPYRIGHT (c) 1998 BY COMPAQ COMPUTER CORPORATION ALL RIGHTS RESERVED.
**
** THIS SOFTWARE IS FURNISHED UNDER A LICENSE AND MAY BE USED AND COPIED
** ONLY  IN  ACCORDANCE  OF  THE  TERMS  OF  SUCH  LICENSE  AND WITH THE
** INCLUSION OF THE ABOVE COPYRIGHT NOTICE. THIS SOFTWARE OR  ANY  OTHER
** COPIES THEREOF MAY NOT BE PROVIDED OR OTHERWISE MADE AVAILABLE TO ANY
** OTHER PERSON.  NO TITLE TO AND  OWNERSHIP OF THE  SOFTWARE IS  HEREBY
** TRANSFERRED.
```

```
**
** THE INFORMATION IN THIS SOFTWARE IS  SUBJECT TO CHANGE WITHOUT NOTICE
** AND  SHOULD  NOT  BE  CONSTRUED  AS A COMMITMENT BY COMPAQ COMPUTER
** CORPORATION.
**
** COMPAQ ASSUMES NO RESPONSIBILITY FOR THE USE  OR  RELIABILITY OF ITS
** SOFTWARE ON EQUIPMENT WHICH IS NOT SUPPLIED BY COMPAQ OR DIGITAL.
**
**=====================================================================
** WARNING - This example is provided for instructional and demo
**           purposes only.  The resulting program should not be
**           run on systems which make use of soft-affinity
**           features of OpenVMS, or while running applications
**           which are tuned for precise processor configurations.
**           We are continuing to explore enhancements such as this
**           program which will be refined and integrated into
**           future releases of OpenVMS.
**=====================================================================
**
** GCU$BALANCER.C - OpenVMS Galaxy CPU Load Balancer.
**
** This is an example of a privileged application which dynamically
** reassigns CPU resources among instances in an OpenVMS Galaxy.  The
** program must be run on each participating instance. Each image will
** create, or map to, a small shared memory section and periodically
** post information regarding the depth of that instances' COM queues.
** Based upon running averages of this data, each instance will
** determine the most, and least busy instance.  If these factors
** exist for a specified duration, the least busy instance having
** available secondary processors, will reassign one of its processors
** to the most busy instance, thereby effectively balancing processor
** usage across the OpenVMS Galaxy.  The program provides command line
** arguments to allow tuning of the load balancing algorithm.
** The program is admittedly shy on error handling.
**
** This program uses the following OpenVMS Galaxy system services:
**
**      SYS$CPU_TRANSITION    - CPU reassignment
**      SYS$CRMPSC_GDZRO_64   - Shared memory creation
**      SYS$SET_SYSTEM_EVENT - OpenVMS Galaxy event notification
**      SYS$*_GALAXY_LOCK_*   - OpenVMS Galaxy locking
**
** Since OpenVMS Galaxy resources are always reassigned via a "push"
** model, where only the owner instance can release its resources,
** one copy of this process must run on each instance in the OpenVMS
** Galaxy.
**
** ENVIRONMENT: OpenVMS V7.2 Multiple-instance Galaxy.
**
** REQUIRED PRIVILEGES:  CMKRNL required to count CPU queues
**                       SHMEM  required to map shared memory
**
** BUILD/COPY INSTRUCTIONS:
**
** Compile and link the example program as described below, or copy the
** precompiled image found in SYS$EXAMPLES:GCU$BALANCER.EXE to
** SYS$COMMON:[SYSEXE]GCU$BALANCER.EXE
**
** If your OpenVMS Galaxy instances utilize individual system disks,
** you will need to do the above for each instance.
**
** If you change the example program, compile and link it as follows:
**
**   $ CC GCU$BALANCER.C+SYS$LIBRARY:SYS$LIB_C/LIBRARY
```

```
**   $ LINK/SYSEXE GCU$BALANCER
**
** STARTUP OPTIONS:
**
** You must establish a DCL command for this program.  We have provided a
** sample command table file for this purpose. To install the new
** command, do the following:
**
**    $ SET COMMAND/TABLE=SYS$LIBRARY:DCLTABLES -
**      /OUT=SYS$COMMON:[SYSLIB]DCLTABLES GCU$BALANCER.CLD
**
** This command inserts the new command definition into DCLTABLES.EXE
** in your common system directory.  The new command tables will take
** effect when the system is rebooted.  If you would like to avoid a
** reboot, do the following:
**
**    $ INSTALL REPLACE SYS$COMMON:[SYSLIB]DCLTABLES.EXE
**
** After this command, you will need to log out, then log back in to
** use the command from any active processes.  Alternatively, if you
** would like to avoid logging out, do the following from each process
** you would like to run the balancer from:
**
**    $ SET COMMAND GCU$BALANCER.CLD
**
** Once your command has been established, you may use the various
** command line parameters to control the balancer algorithm.
**
**    $ CONFIGURE BALANCER{/STATISTICS} x y time
**
** Where: "x" is the number of load samples to take.
**        "y" is the number of queued processes required to trigger
**            resource reassignment.
**        "time" is the delta time between load sampling.
**
** The /STATISTICS qualifier causes the program to display a
** continuous status line.  This is useful for tuning the parameters.
** This output is not visible if the balancer is run detached, as is
** the case if it is invoked via the GCU.  It is intended to be used
** only when the balancer is invoked directly from DCL in a DECterm
** window.
**
** For example: $ CONFIG BAL 3 1 00:00:05.00
**
**        Starts the balancer which samples the system load every
**        5 seconds.  After 3 samples, if the instance has one or
**        more processes in the COM queue, a resource (CPU)
**        reassignment will occur, giving this instance another CPU.
**
** GCU STARTUP:
**
** The GCU provides a menu item for launching SYS$SYSTEM:GCU$BALANCER.EXE
** and a dialog for altering the balancer algorithm.  These features will
** only work if the balancer image is properly installed as described
** the the following paragraphs.
**
** To use the GCU-resident balancer startup option, you must:
**
** 1) Compile, link, or copy the balancer image as described previously.
** 2) Invoke the GCU via: $ CONFIGURE GALAXY   You may need to set your
**    DECwindows display to a suitably configured workstation or PC.
** 3) Select the "CPU Balancer" entry from the "Galaxy" menu.
** 4) Select appropriate values for your system.  This may take some
**    testing.  By default, the values are set aggressively so that
```

```
**    the balancer action can be readily observed.  If your system is
**    very heavily loaded, you will need to increase the values
**    accordingly to avoid excessive resource reassignment.  The GCU
**    does not currently save these values, so you may want to write
**    them down once you are satisfied.
** 5) Select the instance/s you wish to have participate, then select
**    the "Start" function, then press OK.  The GCU should launch the
**    process GCU$BALANCER on all selected instances.  You may want to
**    verify these processes have been started.
**
** SHUTDOWN WARNING:
**
** In an OpenVMS Galaxy, no process may have shared memory mapped on an
** instance when it leaves the Galaxy, as during a shutdown. Because of
** this, SYS$MANAGER:SYSHUTDWN.COM must be modified to stop the process
** if the GCU$BALANCER program is run from a SYSTEM UIC.  Processes in the
** SYSTEM UIC group are not terminated by SHUTDOWN.COM when shutting down
** or rebooting OpenVMS. If a process still has shared memory mapped when
** an instance leaves the Galaxy, the instance will crash with a
** GLXSHUTSHMEM bugcheck.
**
** To make this work, SYS$MANAGER:SYSHUTDWN.COM must stop the process as
** shown in the example below.  Alternatively, the process can be run
** under a suitably privileged, non-SYSTEM UIC.
**
** SYSHUTDWN.COM EXAMPLE - Paste into SYS$MANAGER:SYSHUTDWN.COM
**
**    $!
**    $! If the GCU$BALANCER image is running, stop it to release shmem.
**    $!
**    $ procctx = f$context("process",ctx,"prcnam","GCU$BALANCER","eql")
**    $ procid  = f$pid(ctx)
**    $ if procid .NES. "" then $ stop/id='procid'
**
** Note, you could also just do a "$ STOP GCU$BALANCER" statement.
**
** OUTPUTS:
**
**    If the logical name GCU$BALANCER_VERIFY is defined, notify the
**    SYSTEM account when CPUs are reassigned.  If the /STATISTICS
**    qualifier is specified, a status line is continually displayed,
**    but only when run directly from the command line.
**
** REVISION HISTORY:
**
** 02-Dec-1998 Greatly improved instructions.
** 03-Nov-1998 Improved instructions.
** 24-Sep-1998 Initial code example and integration with GCU.
*/
#include <brkdef>
#include <builtins>
#include <cstdef>
#include <descrip>
#include <glockdef>
#include <ints>
#include <pdscdef>
#include <psldef>
#include <secdef>
#include <ssdef>
#include <starlet>
#include <stdio>
#include <stdlib>
#include <string>
#include <syidef>
```

```
#include <sysevtdef>
#include <vadef>
#include <vms_macros>
#include <cpudef>
#include <iosbdef.h>
#include <efndef.h>
/* For CLI */
#include <cli$routines.h>
#include <chfdef.h>
#include <climsgdef.h>

#define HEARTBEAT_RESTART     0 /* Flags for synchronization           */
#define HEARTBEAT_ALIVE       1
#define HEARTBEAT_TRANSPLANT  2

#define GLOCK_TIMEOUT    100000 /* Sanity check, max time holding gLock */
#define _failed(x) (!( (x) & 1) )

$DESCRIPTOR(system_dsc, "SYSTEM");       /* Brkthru account name   */
$DESCRIPTOR(gblsec_dsc, "GCU$BALANCER"); /* Global section name    */

struct  SYI_ITEM_LIST {              /* $GETSYI item list format */
  short buflen,item;
  void *buffer,*length;
};

/* System information and an item list to use with $GETSYI */

static unsigned long total_cpus;
static uint64   partition_id;
static long     max_instances = 32;
iosb            g_iosb;

struct SYI_ITEM_LIST syi_itemlist[3] = {
     {sizeof (long), SYI$_ACTIVECPU_CNT,&total_cpus;,  0},
     {sizeof (long), SYI$_PARTITION_ID, &partition_id;,0},
     {0,0,0,0}};

extern uint32 *SCH$AQ_COMH;          /* Scheduler COM queue address */
unsigned long PAGESIZE;              /* Alpha page size             */
uint64        glock_table_handle;    /* Galaxy lock table handle    */

/*
** Shared Memory layout (64-bit words):
** ====================================
** 0  to  n-1:  Busy count, where 100 = 1 process in a CPU queue
** n  to  2n-1: Heartbeat (status) for each instance
** 2n to  3n-1: Current CPU count on each instance
** 3n to  4n-1: Galaxy lock handles for modifying heartbeats
**
** where n = max_instances * sizeof(long).
**
** We assume the entire table (easily) fits in two Alpha pages.
*/

/* Shared memory pointers must be declared volatile */

volatile uint64  gs_va = 0;          /* Shmem section address     */
volatile uint64  gs_length = 0;      /* Shmem section length      */
volatile uint64 *gLocks;             /* Pointers to gLock handles */
volatile uint64 *busycnt,*heartbeat,*cpucount;

/*****************************************************************/
/* FUNCTION init_lock_tables - Map to the Galaxy locking table and   */
```

```
/* create locks if needed. Place the lock handles in a shared memory */
/* region, so all processes can access the locks.                    */
/*                                                                   */
/* ENVIRONMENT: Requires SHMEM and CMKRNL to create tables.          */
/* INPUTS:      None.                                                */
/* OUTPUTS:     Any errors from lock table creation.                 */
/*********************************************************************/
int init_lock_tables (void)
{
    int status,i;
    unsigned long sanity;
    uint64 handle;
    unsigned int min_size, max_size;

/* Lock table names are 15-byte padded values, unique across a Galaxy.*/
   char table_name[] = "GCU_BAL_GLOCK  ";

/* Lock names are 15-byte padded values, but need not be unique. */
   char lock_name[] = "GCU_BAL_LOCK   ";

/* Get the size of a Galaxy lock */
 status = sys$get_galaxy_lock_size(&min_size,&max_size);
 if (_failed(status) ) return (status);

    /*
    ** Create or map to a process space Galaxy lock table. We assume
    ** one page is enough to hold the locks. This will work for up
    ** to 128 instances.
    */
    status = sys$create_galaxy_lock_table(table_name,PSL$C_USER,
                PAGESIZE,GLCKTBL$C_PROCESS,0,min_size,&glock_table_handle)
    if (_failed(status) ) return (status);

    /*
    ** Success case 1: SS$_CREATED
    ** We created the table, so  populate it with locks and
    ** write the handles to shared memory so the other partitions
    ** can access them. Only one instance can receive SS$_CREATED
    ** for a given lock table; all other mappers will get SS$_NORMAL.
    */
    if (status == SS$_CREATED)
    {
      printf ("%%GCU$BALANCER-I-CRELOCK, Creating G-locks\n");
      for (i=0; i<max_instances>pdsc$q_entry[0];
   sub_addr[1] = sub_addr[0] + PAGESIZE;
   if (__PAL_PROBER( (void *)sub_addr[0],sizeof(int),PSL$C_USER) != 0)
        sub_addr[1] = sub_addr[0];

   status = sys$lkwset(sub_addr,locked_code,PSL$C_USER);
   if (_failed(status) ) exit(status);
}

/*********************************************************************/
/* FUNCTION reassign_a_cpu - Reassign a single CPU to another        */
/* instance.                                                         */
/*                                                                   */
/* ENVIRONMENT: Requires CMKRNL privilege.                           */
/* INPUTS:      most_busy_id: partition ID of destination.           */
/* OUTPUTS:     None.                                                */
/*                                                                   */
/* Donate one CPU at a time - then wait for the remote instance to   */
/* reset its heartbeat and recalculate its load.                     */
/*********************************************************************/
void reassign_a_cpu(int most_busy_id)
```

```
{
  int status,i;
  static char op_msg[255];
  static char iname_msg[1];
  $DESCRIPTOR(op_dsc,op_msg);
  $DESCRIPTOR(iname_dsc,"");
  iname_dsc.dsc$w_length = 0;

  /* Update CPU info */

  status = sys$getsyiw(EFN$C_ENF,0,0,&syi_itemlist, &g_iosb,0,0);
  if (_failed(status) ) exit(status);

  /* Don't attempt reassignment if we are down to one CPU */

  if (total_cpus > 1)
  {
  status = sys$acquire_galaxy_lock(gLocks[most_busy_id],GLOCK_TIMEOUT,0);
  if (_failed(status) ) exit(status);
  heartbeat[most_busy_id] = HEARTBEAT_TRANSPLANT;
  status = sys$release_galaxy_lock(gLocks[most_busy_id]);
  if (_failed(status) ) exit(status);

  status = sys$cpu_transitionw(CST$K_CPU_MIGRATE,CST$K_ANY_CPU,0,
                               most_busy_id,0,0,0,0,0,0);
  if (status & 1)
  {
    if (getenv ("GCU$BALANCER_VERIFY") )
    {
      sprintf(op_msg,
             "\n\n*****GCU$BALANCER: Reassigned a CPU to instance %li\n",
             most_busy_id);
      op_dsc.dsc$w_length = strlen(op_msg);
      sys$brkthru(0,&op_dsc,&system_dsc,BRK$C_USERNAME,0,0,0,0,0,0,0);
      }
      update_cpucount(0);  /* Update the CPU count after donating one */
    }
  }
}

/*****************************************************************/
/* IMAGE ENTRY - MAIN                                            */
/*                                                               */
/* ENVIRONMENT: OpenVMS Galaxy                                   */
/* INPUTS:      None.                                            */
/* OUTPUTS:     None.                                            */
/*****************************************************************/
int main(int argc, char **argv)
{
   int           show_stats = 0;
   long          busy,most_busy,nprocs;
   int64         delta;
   unsigned long status,i,j,k,system_cpus,instances;
   unsigned long arglst         = 0;
   uint64        version_id[2]  = {0,1};
   uint64        region_id      = VA$C_P0;
   uint64        most_busy_id,cpu_hndl = 0;

/* Static descriptors for storing parameters.  Must match CLD defs */

  $DESCRIPTOR(p1_desc,"P1");
  $DESCRIPTOR(p2_desc,"P2");
  $DESCRIPTOR(p3_desc,"P3");
  $DESCRIPTOR(p4_desc,"P4");
```

```
  $DESCRIPTOR(stat_desc,"STATISTICS");

/* Dynamic descriptors for retrieving parameter values */

  struct dsc$descriptor_d samp_desc = {0,DSC$K_DTYPE_T,DSC$K_CLASS_D,0};
  struct dsc$descriptor_d proc_desc = {0,DSC$K_DTYPE_T,DSC$K_CLASS_D,0};
  struct dsc$descriptor_d time_desc = {0,DSC$K_DTYPE_T,DSC$K_CLASS_D,0};

  struct SYI_ITEM_LIST syi_pagesize_list[3] = {
    {sizeof (long), SYI$_PAGE_SIZE      , &PAGESIZE    ,0},
    {sizeof (long), SYI$_GLX_MAX_MEMBERS,&max_instances,0},
    {0,0,0,0}};
/*
** num_samples and time_desc determine how often the balancer should
** check to see if any other instance needs more CPUs. num_samples
** determines the number of samples used to calculate the running
** average, and sleep_dsc determines the amount of time between
** samples.
**
** For example, a sleep_dsc of 30 seconds and a num_samples of 20 means
** that a running average over the last 10 minutes (20 samples * 30 secs)
** is used to balance CPUs.
**
** load_tolerance is the minimum load difference which triggers a CPU
** migration. 100 is equal to 1 process in the computable CPU queue.
*/
   int num_samples;     /* Number of samples in running average      */
   int load_tolerance;  /* Minimum load diff to trigger reassignment */

/* Parse the CLI */
                                              /* CONFIGURE VERB */
   status      = CLI$PRESENT(&p1_desc);       /* BALANCER       */
   if (status != CLI$_PRESENT) exit(status);
   status      = CLI$PRESENT(&p2_desc);       /* SAMPLES        */
   if (status != CLI$_PRESENT) exit(status);
   status      = CLI$PRESENT(&p3_desc);       /* PROCESSES      */
   if (status != CLI$_PRESENT) exit(status);
   status      = CLI$PRESENT(&p4_desc);       /* TIME           */
   if (status != CLI$_PRESENT) exit(status);

   status     = CLI$GET_VALUE(&p2_desc,&samp_desc);
   if (_failed(status) ) exit(status);
   status     = CLI$GET_VALUE(&p3_desc,&proc_desc);
   if (_failed(status) ) exit(status);
   status     = CLI$GET_VALUE(&p4_desc,&time_desc);
   if (_failed(status) ) exit(status);
   status     = CLI$PRESENT(&stat_desc);
   show_stats = (status == CLI$_PRESENT) ? 1 : 0;

   num_samples = atoi(samp_desc.dsc$a_pointer);
   if (num_samples <= 0) num_samples = 3;

   load_tolerance = (100 * (atoi(proc_desc.dsc$a_pointer) ) );
   if (load_tolerance <= 0) load_tolerance = 100;

   if (show_stats)
     printf("Args: Samples: %d, Processes: %d, Time: %s\n",
        num_samples,load_tolerance/100,time_desc.dsc$a_pointer);

   lockdown();                  /* Lock down the cpu_q subroutine */

   /* Get the page size and max members for this system */

   status = sys$getsyiw(EFN$C_ENF,0,0,&syi_pagesize_list,&g_iosb,0,0);
```

```
   if (_failed(status) ) return (status);

   if (max_instances == 0) max_instances = 1;

   /* Get our partition ID and initial CPU info */

   status = sys$getsyiw(EFN$C_ENF,0,0,&syi_itemlist,&g_iosb,0,0);
   if (_failed(status) ) return (status);

   /* Map two pages of shared memory */

status = sys$crmpsc_gdzro_64(&gblsec_desc,version_id,0,PAGESIZE+PAGESIZE,
         &region_id,0,PSL$C_USER,(SEC$M_EXPREG|SEC$M_SYSGBL|SEC$M_SHMGS),
         &gs_va,&gs_length);
if (_failed(status) ) exit(status);

   /* Initialize the pointers into shared memory */

   busycnt   = (uint64 *) gs_va;
   heartbeat = (uint64 *) gs_va     + max_instances;
   cpucount  = (uint64 *) heartbeat + max_instances;
   gLocks    = (uint64 *) cpucount  + max_instances;

   cpucount[partition_id] = total_cpus;

   /* Create or map the Galaxy lock table */

   status = init_lock_tables();
   if (_failed(status) ) exit(status);

   /* Initialize delta time for sleeping */

   status = sys$bintim(&time_desc,δ);
   if (_failed(status) ) exit(status);

   /*
   ** Register for CPU migration events. Whenever a CPU is added to
   ** our active set, the routine "update_cpucount" will fire.
   */
   status = sys$set_system_event(SYSEVT$C_ADD_ACTIVE_CPU,
              update_cpucount,0,0,SYSEVT$M_REPEAT_NOTIFY,&cpu_hndl);
   if (_failed(status) ) exit(status);

   /* Force everyone to resync before we do anything */

   for (j=0; j<max_instances; j++)
   {
     status = sys$acquire_galaxy_lock(gLocks[j],GLOCK_TIMEOUT,0);
     if (_failed(status) ) exit(status);
     heartbeat[j] = HEARTBEAT_RESTART;
     status = sys$release_galaxy_lock (gLocks[j]);
     if (_failed(status) ) exit(status);
   }

   printf("%%GCU$BALANCER-S-INIT, CPU balancer initialized.\n\n");

   /*** Main loop ***/
   do
   {
     /* Calculate a running average and update it */

     nprocs = sys$cmkrnl(cpu_q,&arglst) * 100;

/* Check out our state... */
```

```
switch (heartbeat[partition_id])
{
  case HEARTBEAT_RESTART: /* Mark ourself for reinitializition. */
  {
    update_cpucount(0);
    status = sys$acquire_galaxy_lock(gLocks[partition_id],GLOCK_TIMEOUT,0);
    if (_failed(status) ) exit(status);
    heartbeat[partition_id] = HEARTBEAT_ALIVE;
    status = sys$release_galaxy_lock(gLocks[partition_id]);
    if (_failed(status) ) exit(status);
    break;
  }
  case HEARTBEAT_ALIVE: /* Update running average and continue. */
  {
    busy = (busycnt[partition_id]*(num_samples-1)+nprocs)/num_samples;
    busycnt[partition_id] = busy;
    break;
   }
   case HEARTBEAT_TRANSPLANT:  /* Waiting for a new CPU to arrive. */
   {
    /*
     ** Someone just either reset us, or gave us a CPU and put a wait
     ** on further donations.  Reassure the Galaxy that we're alive,
     ** and calculate a new busy count.
      */
     busycnt[partition_id] = nprocs;
     status = sys$acquire_galaxy_lock(gLocks[partition_id],GLOCK_TIMEOUT,0);
     if (_failed(status) ) exit(status);
     heartbeat[partition_id] = HEARTBEAT_ALIVE;
     status = sys$release_galaxy_lock(gLocks[partition_id]);
     if (_failed(status) ) exit(status);
     break;
   }
   default:         /* This should never happen. */
   {
     exit(0);
     break;
   }
  }

  /* Determine the most_busy instance. */

  for (most_busy_id=most_busy=i=0; i<max_instances; i++)
  {
    if (busycnt[i] > most_busy)
    {
      most_busy_id = (uint64) i;
      most_busy    = busycnt[i];
    }
  }

  if (show_stats)
    printf("Current Load: %3Ld, Busiest Instance: %Ld, Queue Depth: %4d\r",
          busycnt[partition_id],most_busy_id,(nprocs/100) );

  /* If someone needs a CPU and we have an extra, donate it. */

   if ( (most_busy > busy + load_tolerance) &&
       (cpucount[partition_id] > 1) &&
       (heartbeat[most_busy_id] != HEARTBEAT_TRANSPLANT) &&
       (most_busy_id != partition_id) )
     {
        reassign_a_cpu(most_busy_id);
```

```
    }

    /* Hibernate for a while and do it all again. */

    status = sys$schdwk(0,0,δ,0);
    if (_failed(status) ) exit(status);
    status = sys$hiber();
    if (_failed(status) ) exit(status);

  } while (1);
  return (1);
}
```

B Common Values for Setting Memory Size

Table B-1 lists common values for Galaxy environment variables that can be used to set memory size. All values are expressed in hexadecimal bytes.

Table B-1 Common Values for Memory Size Environment Variables

1 MB	0x 10 0000
2 MB	0x 20 0000
4 MB	0x 40 0000
8 MB	0x 80 0000
16 MB	0x 100 0000
32 MB	0x 200 0000
64 MB	0x 400 0000
128 MB	0x 800 0000
256 MB	0x 1000 0000
448 MB	0x1C00 0000
512 MB	0x 2000 0000
1 GB	0x 4000 0000
2 GB	0x 8000 0000
4 GB	0x 1 0000 0000
8 GB	0x 2 0000 0000
16 GB	0x 4 0000 0000
32 GB	0x 8 0000 0000
64 GB	0x 10 0000 0000
128 GB	0x 20 0000 0000
256 GB	0x 40 0000 0000
512 GB	0x 80 0000 0000
1 TB	0x 100 0000 0000

C Installing Licenses

This appendix contains information on how to share license units in hard and soft partitions.

License Process

To ensure that the common license database can share license units among hard and soft partitions, when supported, perform the following steps:

1. Calculate required units.
   - Load the base OpenVMS license.
   - Load the SMP licenses.
   - Use the command `SHOW LICENSE /UNIT_REQUIREMENTS /CLUSTER` to verify that you have the correct number of license units.

NOTE An SMP license is required for an interactive login; the base OpenVMS license does not allow an interactive login.

2. Add your licenses to the common license database. For example:

```
$ LICENSE REGISTER OPENVMS-ALPHA /ISSUER=DEC -
_$ /AUTHORIZATION=USA123456 -
_$ /PRODUCER=DEC -
_$ /UNITS=1050 -
_$ /AVAILABILITY=H -
_$ /OPTIONS=(NO_SHARE) -
_$ /CHECKSUM=2-BGON-IAMA-GNOL-AIKO
```

NOTE You cannot use the /INCLUDE qualifier with the LICENSE REGISTER command to override the NO_SHARE attribute of the license.

3. Modify the license to override the NO_SHARE attribute of the PAKs with the command LICENSE MODIFY /INCLUDE=(*nodename-list).* For example:

```
$ LICENSE MODIFY OPENVMS-ALPHA -
_$ /AUTHORIZATION=USA123456 -
_$ /INCLUDE=(NODEA, NODEb, NODEC)
```

4. To make OpenVMS Alpha license units availalbe to the instance of OpenVMS running in each partition, you must ensure that the MBM environment variable SYS_SERIAL_NUM is the same in each partition. To do so, perform the following steps:
   a. From the MBM console, use the SHOW SYS_SERIAL_NUM command to display the system serial number. For example:

```
MBM>>>SHOW SYS_SERIAL_NUM
sys_serial_num G2A105
```

b. If the value of SYS_SERIAL _NUM is blank, use the SET SYS_SERIAL_NUM command at the MBM console to set the system serial number. The system serial number is propagated to every partition, hard or soft. For example:

```
MBM>>>SET SYS_SERIAL_NUM G2A105
```

NOTE You must enter a nonzero value of up to 12 characters. (Earlier systems supported 16-character values.) Ensure that the system serial number that you creae is not used on any other AlphaServer system on this OpenVMS Cluster.

---

5. To correctly update the OpenVMS Cluster license database, HP recommends that you completely shut down and reboot all OpenVMS Cluster common nodes. A rolling upgrade does not correctly update the common license database.

For partitionable systems that share NO_SHARE licenses across partitions, the following messages may appear when the system boots:

```
%LICENSE-E-NOAUTH, DEC OPENVMS-ALPHA use is not authorized on this node
-LICENSE-F-EXCEEDED, attempted usage exceeds active license limits
-LICENSE-I-SYSMGR, please see your system manager
Startup processing continuing...
```

You can safely ignore these messages. They appear when you have logged onto a system that is actively sharing the OPENVMS-ALPHA PAK. This will be fixed in a future release.

For Additional Licensing Information

For more information about installing and managing license, refer to the *OpenVMS License Management Utility Manual*.

Glossary

C

community The software entity that enables the sharing of resources such as memory.

configuration tree The representation of system components in a diagram with a branching form.

G

Galaxy An implementation of soft partitions on OpenVMS.

H

hard partition A set of computing resources physically separated by hardware-enforced access barriers.

I

instance A running operating system.

M

mutex A resource semaphore.

N

node A point of connection in a configuration tree.

non-Galaxy system A system that is not running Galaxy, or for which Galaxy has not been turned on.

S

soft partition A set of computing resources separated by software-controlled access barriers.

spinlock Repeatedly checking the status of a bitlock.